A HANDBOOK OF

BRIQUETTING.

VOLUME I.

A HANDBOOK OF
BRIQUETTING.

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IN TWO VOLUMES—EACH COMPLETE IN ITSELF AND SOLD SEPARATELY.

VOLUME I.

THE BRIQUETTING OF COALS, BROWN COALS, AND OTHER FUELS.

With 9 Plates and 225 Illustrations in the Text.

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PREFACE.

BEFORE the publication of the German edition of this book there was no work dealing with the methods used in the briquetting industry, and the author has attempted to fill the gap.

The industry, which is constantly increasing in importance, was formerly divided into two main branches, viz. the briquetting of pit coals and the briquetting of brown coals (including the preparation of wet-compressed blocks), and these two branches are treated of in this first volume. The subject is dealt with in its technical, legal, economical, and statistical relationships. Description of the individual methods and appliances is effected in a very thorough manner by illustrations and brief descriptions of a number of modern briquette factories; and the properties and methods of application of the products are considered in detail. An appendix gives a concise review of the production of mixed, other fuel, and salt briquettes.

A second and shorter volume will follow soon, and will have for its object the description of the briquetting of ores, metallurgical products, metal swarf, etc., and also of agglomeration. These branches of the industry have opened out and considerably developed during the last few years.

The book is primarily intended as a handbook for those actively engaged in, or connected with, the industry in any of its technical or commercial aspects. It is also intended as a text-book in Schools of Mining and Metallurgy and Technical High Schools, more particularly where particular emphasis is laid upon a thorough instruction in the methods of briquetting. May it be favourably received and fulfil its object!

G. FRANKE.

BERLIN.

TRANSLATOR'S PREFACE.

No apology is needed for the publication of this book, since the literature of the subject of Briquetting is scanty, and is, in fact, almost wholly confined to various technical journals, few of which are distinguished by their accessibility.

A perusal of the work will convince the reader of the complete and detailed character of the information contained in it. The author is undoubtedly master of his subject, and the chief concern of the translator has been to present a faithful interpretation of the original matter to the English technical reader.

Some apology is undoubtedly due for the somewhat tardy appearance of the translation, but the national crisis has made considerable inroads into the time of the translator. Probably, however, the work could not have had a more opportune moment for its appearance than the present. At no time in our history has it been so important that we should make the most of our national resources, and all methods which tend towards the economical utilisation of our raw materials should receive the most careful consideration. By the application of the methods of briquetting fuel, smalls can be converted into a form in which they can be burnt readily and economically, fine ores and other metallurgical products can be turned to account by adapting them to the various smelting processes, the metal swarf from engineering shops can be utilised effectively, and so on. Naturally, it is in its application to fuels that briquetting has been most completely developed. The Germans do not enjoy the advantage of possessing almost unlimited supplies of hard coal. Much of their fuel would be counted very poor material in this country, and the result has been that they have been compelled to develop the methods of briquetting, not only with the object of getting the fuel into a form in which it can be burnt, but also with the object of treating it so that it is worth burning. Since in our own country the supply of fuel is of the highest quality, it should be the more profitable to undertake the briquetting of fine coals.

The object of the book has been stated fairly clearly by the author, and the object of the translation is to put in the possession of English industrial leaders knowledge which other countries have been compelled to acquire.

In the various cost sheets which appear it has not been thought necessary to convert marks into their English equivalents. After all, the question of cost ultimately resolves itself largely into one of local conditions, so that the worth of the figures is to be found in their inter-relationship rather than in their absolute values. Approximate conversion into English money can, however, be effected readily by dividing by twenty.

In conclusion, a tribute should be paid to the publishers for their foresight in adding this book to their already extensive list of technical publications.

FRED. C. A. H. LANTSBERRY.

BIRMINGHAM, *January* 1916.

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BRIQUETTES AND BRIQUETTING.

INTRODUCTION.

SCOPE AND NATURE OF BRIQUETTING.

THE word "briquette" is of French origin (from *brique* = a brick), and was originally applied to the fuel blocks, prepared from peat by admixture with loam and water, at one time introduced into Paris, and later to the compressed coal obtained by subjecting heated bituminous small coal to considerable pressure.

Nowadays the term "briquettes" includes in its widest sense all kinds of artificially moulded fuels, and indeed all materials brought into the solid form by strongly compressing smalls or dusts, *e.g.* ores and metallurgical products, with or without a special binding material. In the narrow sense, however, it is only applied to the coal and brown-coal briquettes obtained from natural coal dust. In Germany, if one speaks or writes simply of "briquettes," one or the other or both varieties of pressed coal are referred to, briquettes of other materials being defined by prefixing the name of the composing material, *e.g.* peat briquettes, ore briquettes.

"Coal stones" (*Kohlensteine*), "coal bricks" (*Kohlenziegel*) are local, essentially colloquial expressions for coal briquettes, while brown-coal briquettes are called *Darrsteine, Darrkohlensteine* (kiln-dried coal), to distinguish them from the lesser valued *Nasspress-steinen* (moist-pressed stones).

In other countries the following terms are applied to coal briquettes:—

In France and Belgium: *charbons agglomérés, houilles agglomérées* or simply *agglomérés, briquettes de charbon*; in England and North America: *patent fuel, compressed fuel, briquettes.* All classes of

artificially moulded fuels are included under the terms *combustibles artificiels agglomérés* and *artificial fuels*.

Briquetting must be considered as a branch of dressing, since, like the latter, it resolves itself into a mechanical improvement of, and renders marketable, certain mine products which otherwise could not be sold or would fetch an insufficient price to be profitable.

This improvement by briquetting is effected in the case of coal and peat by concentration and remoulding, which form a very important part of dressing, considered in the narrow sense. Whilst the improvement of raw products consists mostly of separating the foreign solid mineral matter, accompanied by pulverising or sorting according to size, briquetting consists in freeing the useful, fine purified material from excess water and moulding and compressing it into solid artificial stones of certain definite shapes. Strictly speaking, the admixture of special binding materials in the briquetting of materials like coals, and heating for the purposes of drying or softening, cannot be regarded as part of the dressing.

Chemical changes either do not take place or do so only to a very limited extent in the ordinary processes of briquetting, in which sense it differs essentially from coking, heap burning, and all other methods of dealing with coals and brown coals in which their chemical composition is considerably altered. On the other hand, briquetting has much in common with the making of bricks and artificial stones.

HISTORY OF BRIQUETTING.

Briquetting has developed from the simple ball shaping and hand moulding used of old in many coal-producing districts (Saxony, Rheinland (Aachen), Liège, France, Austria, Pennsylvania, China, etc.), and in fact partly used to this day.

The Aachen and certain Rhenish cylindrical blocks, as well as the Liège "boulets," "hochets," and "plaquisses," consist of a mixture of coal (refuse, slack and dust, and in earlier times of much earthy coal from the debris of the seam) with 10–15 per cent of loam, 15–20 per cent. of clay, or 8 per cent of plastic clay, which is moistened and moulded into spherical or brick-shaped moulds and dried in the chimney flue for use as house fuel.

The truncated Rhenish lignite blocks used in more recent times are prepared in a similar manner, but without additions, as is illustrated in fig. 1.

Fig. 1.—Lower Rhenish block-briquetting of lignite smalls.
(Susanna Mining Company.)

In Central Germany (Saxony, Thuringia, Hessia), however, the earthy lignite is mixed with water, occasionally clay is added, the whole is thoroughly kneaded with the feet, rammed into rectangular moulds, and allowed to dry and harden in the air, very much in the same way as clay and peat bricks are made.

These pressed coals were not, however, a very valuable product, since their low calorific value and strength, and their high content of ash and moisture, did not allow of their being transported long distances, or of their general application as fuels. Consequently, the market was limited to the immediate neighbourhood of the producing districts.

Towards the end of the eighteenth and in the first half of the nineteenth century the hitherto unimportant coal-mining industry rapidly extended and a systematic development of the rich brown-coal deposits gradually took place. Continually increasing quantities of unsaleable smalls accumulated and were often lost by spontaneous ignition. Consequently, the efforts to prepare marketable pressed coals increased until, after many laborious attempts marked by many failures and few successful results, the preparation of pressed coals or briquettes possessing all the necessary properties for technical use became an accomplished commercial fact.

Generally speaking, the properties demanded were, and are still, as follows:—regular, even shape, suitable size, uniform composition, uniform weight, greatest possible strength and calorific power, capability of handling and storage so that the briquettes can be transported long distances by sea or land, or can be kept in the open or under light cover for long periods without suffering much change.

They must be subject to very little change in colour, must not soil the hands, be almost odourless, easily ignited, and burn completely with a long bright flame, and as little soot and smoke as possible: they must not crumble in the fire, and must leave little ash and clinker.

It had already been shown in earlier experiments that the very different nature of the principal coals under consideration—some hard, slightly porous, and fairly dry, others soft, earthy lignites—do not allow of working in the same manner. As a matter of fact, the methods of preparation of pressed coals and brown coals are distinct from the outset according to the geographical position of the chief centres of experiment and manufacture (France, England, Belgium, and Rhenish Westphalia on the one hand, and Central Germany on the other) which have contributed the material. Although the ultimate objects were identical, each branch of briquetting had its own special

problems for solution and difficulties to overcome, of which it is only necessary to refer to the following here:—

Coals require a special and not too costly binding material which must be added in definite proportions, intimately mixed with the coal, and the whole heated to a certain temperature. Drying is only necessary to a limited extent, principally with washed coals, and is easily accomplished. The pressures applied vary from 200 to 300 atmospheres, and the whole process is apparently without danger.

The earthy brown coals, however, can be briquetted without any bond, but on account of their high content of water require prolonged drying with continuous turning over to expose fresh surfaces. They yield a considerable amount of dust, which is extraordinarily inflammable and explosive. Considerable trouble is experienced therefore in avoiding danger. Pressing is completed under a final pressure of 1200–1500 atmospheres,

The briquetting of coal on a manufacturing scale began about the year 1860, and of lignite about ten years later (see below). Since then, and especially during the last ten years, the manufacture of pressed coals has developed into an extraordinarily important and prosperous industry, in which huge quantities of almost valueless coal have been converted into fuel of the highest value for various purposes. In this way the national wealth has been increased and many thousands of people have been employed.

The German Empire occupies the first place in the briquetting countries of the world. Until a short time ago, brown-coal briquetting was almost exclusively a German industry; while, in the total world production of coal briquettes, other countries, principally Belgium, France, England, and Austria-Hungary and the U.S.A., possess only a comparatively small share. (See "Briquette Statistics," at the conclusion of Parts I. and II.)

The market and application of the pressed coals differ according to their special properties or those of the parent raw materials. Coal briquettes are mainly used on railways and in steamships, the remainder find industrial application and, to a slight extent, as house fuels in the vicinity of their manufacture. Most of the brown-coal briquettes are used as house fuels in the large towns, a considerable number are now being used in industries, and only a proportionally small residue is consumed on railways and in steamships.

The moist-pressed blocks prepared from lignites do not permit of being sent very far, and their sale is limited to the immediate

vicinity of the works, where the cheap blocks are used as house fuels in brick-kilns and other industrial pursuits.

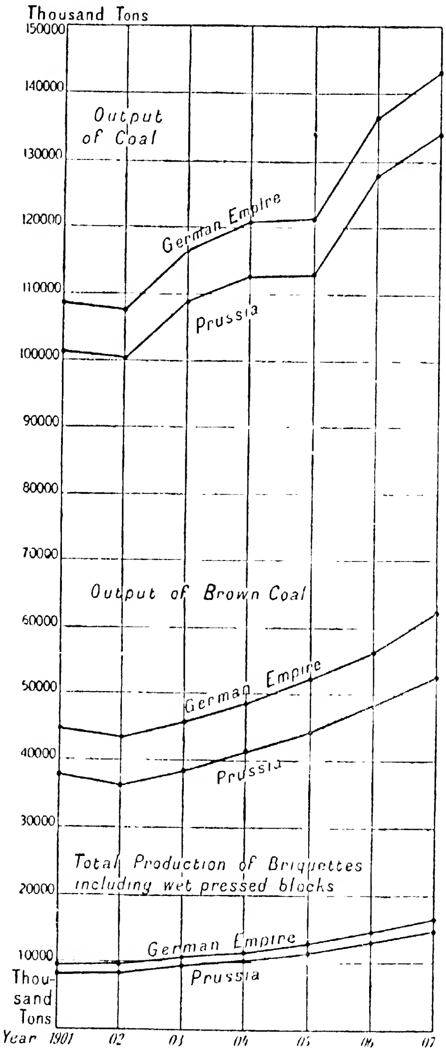


FIG. 2.

The briquetting of peat and other fuels (bituminous shale, sawdust, logwood shavings, resin residues, residues from olive-oil manufacture, sawmills' shavings, etc.) has not attained much importance in spite of many recent experiments. With peat, to be principally considered here, the chief difficulty lies in the high content of water (85 per cent. and upwards), which must be reduced to about 20 per cent. at the least possible cost to ensure industrial success.

The briquetting of the fines, slimes, and dust derived from ores and furnace products, such as certain iron ores, de-coppered burnt pyrites, cement copper, flue dust, and so on, for the purpose of smelting or other methods of working up, was until recently a very difficult economical problem. Their treatment by the various methods of brick-making with or without the use of a bond has only been accomplished in the most recent times This opened to briquetting a new field of great importance, since considerable and continually increasing quantities of mineral matters and products, hitherto of low value

OUTPUT OF COAL AND PRODUCTION OF BRIQUETTES IN THE GERMAN EMPIRE BETWEEN 1901 AND 1907.

(Derived from the Commercial and Industrial Press of the Mining Company's Statistics.)

Producing District.	1901 Pit Coals 1000 Tons	1901 Brown Coals 1000 Tons	1901 Briquettes and wet Compressed Blocks 1000 Tons	1902 Pit Coals 1000 Tons	1902 Brown Coals 1000 Tons	1902 Briquettes and wet Compressed Blocks 1000 Tons	1903 Pit Coals 1000 Tons	1903 Brown Coals 1000 Tons	1903 Briquettes and wet Compressed Blocks 1000 Tons	1904 Pit Coals 1000 Tons	1904 Brown Coals, 1000 Tons.	1904 Briquettes and wet Compressed Blocks, 1000 Tons.
Breslau Mining Commission	29,961 1	915 4	156 5	29,955 0	978 9	167 5	30,185 2	938 4	190 2	30,643 0	1,083 4	239 5
Halle a S do	11 2	29,657 5	4,823 1	9 9	29,339 9	4,970 6	8 0	30,815 5	5,128 6	7 0	32,582·7	6,130·4
Clausthal do	681 9	650 0	51 6	681 1	601 0	—	709 6	632 4	18 0	724 3	692 1	662 2
Dortmund do	58,417 6	—	1,340 7	58,055 6	—	1,652 0	64,689 6	—	1,826 9	67,533 7	—	1,890 1
Bonn do do	12,102 0	6,238 5	1,559 4	12,527 7	5,161 4	—	13,256 8	6,046 5	1,300 0	13,847 6	6,795 3	1,780 2
Prussia . .	101,203 8	37,491 4	8,131 3	100,260 5	36,228 2	8,111 3	108,809 3	38,462 8	9,173 7	112,755 6	41,153 5	10,102 4
Saxony . .	4,759 8	1,635 0	209 5	4,649 1	1,746 9	235 8	4,698 1	1,828 1	277 2	4,803 5	1,922 1	800 9
Bavaria . .	1,203 8	25 2	—	1,233 5	27 3	—	1,360 9	16 5	—	1,311 9	53 5	..
Alsace-Lorraine	1,193 1	—	—	1,309 8	—	—	1,599 6	—	—	1,708 5	—	—
Hessia .	—	—	—	—	296 7	—	.	—	51 1	—	373 4	57 6
Saxon-Altenburg	—	2,117 0	417 1	—	2,181 7	120 2	.	2,283 8	190 5	..	2,262 7	517 7
Brunswick .	—	1,436 3	310 1	—	1,307 8	293 3	0 3	1,585 4	345 2	—	1,440 2	271 5
Anhalt . .	—	1,366 0	134 4	—	1,278 1	116 3	..	1,376 7	138 4	—	1,376 7	163 0
Other German States	178 9	379 1	49 1	21 0	59 9	37 2	—	—	—	206 0	52 8	..
German Empire	108,539 4	44,480 0	9,251 5	107,173 9	43,126 3	9,214 1	116,637 7	45,819 5	10,476 1	120,815 5	48,635 0	11,413 5

Producing District	1905 Pit Coals 1000 Tons	1905 Brown Coals 1000 Tons	1905 Briquettes and wet Compressed Blocks 1000 Tons	1906 Pit Coals 1000 Tons	1906 Brown Coals 1000 Tons	1906 Briquettes and wet Compressed Blocks 1000 Tons	1907 Pit Coals 1000 Tons.	1907 Brown Coals 1000 Tons	1907 Briquettes and wet Compressed Blocks 1000 Tons
Breslau Mining Commission	32,319 2	1,196 1	381 4	35,062 7	1,367 9	366 4			..
Halle a S do	6 6	31,189 7	6,619 7	10 6	36,022 0	7,197 4			..
Clausthal do	755 2	781 5	116 4	718 6	815 1	111 1			..
Dortmund do	65,375 5		2,256 1	76,811 0		2,689 0			.
Bonn do do	14,566 1	7,961 3	2,100 2	15,663 0	9,707 4	2,531 5			
Prussia . .	113,000 6	44,148 7	11,503 8	128,295 9	47,912 7	12,928 4	134,303 0	52,674 2	14,530 2
Saxony	4,913 0	2,167 7	363 1	4,812 8	2,314 1	387 9			
Bavaria .	1,518 0	122 4		1,381 1	134 3				
Alsace-Lorraine	1,823 7			2,071 6				.	
Hessia .		422 1	65 1		430 1	62 2			.
Saxon-Altenburg		2,408 5	563 0		2,234 5	541 6			..
Brunswick .		1,725 2	323 6		1,770 7	369 9			..
Anhalt . .	.	1,401 8	191 1		1,415 1	210 9		..	..
Other German States.		52 6			14 0			..	
German Empire.	121,298 6	52,512 0	13,009 7	136,561 4	56,255 8	14,500 9	143,222 9	62,319 8	16,415 5

and often a nuisance, could be treated so as to become useful products.

The same remark applies to all classes of metal swarf such as filings, turnings, and planings of iron, steel, copper, bronze, brass, white metal, and the like, which can now be converted into briquettes (metal briquettes) possessing valuable properties. Further, in some districts the briquetting of salt is carried out.

"Agglomeration" of fines or slimes in which the materials are baked or fritted together into more or less large shapeless lumps without pressure, although closely related to briquetting, can hardly be regarded as true briquetting.

This simple method has made considerable progress, and will probably compete seriously with the true ore-briquetting industry. Broadly speaking, the domain of briquetting is very wide, and has a promising future, but it appears that coal and brown-coal briquetting will always take the first place in importance.

The extent of the total preparation of coal briquettes and moist-pressed blocks, in the German Empire and its individual states, together with the output of coal and brown coal, is shown by the curves in fig. 2 and in the tables collected from the sources indicated in the sequel.

As a matter of fact, the manufacture of briquettes is greater than that shown by several hundred thousand tons yearly, since the output of a number of coal-briquetting plants situated outside the coal area, namely, the Upper Rhine, are not included in the official and semi-official statistics. (For further information see under "Statistics of Coal Briquetting," in Section XI. of Part I.)

PART I.

PREPARATION OF COAL BRIQUETTES.

SECTION I.

HISTORICAL ACCOUNT; PROPERTIES AND APPLICATION OF COAL BRIQUETTES.

A. HISTORICAL ACCOUNT.

THE original preparation of pressed coals for domestic fuels in blocks (*Klütten, boulets, hochets*) from moistened mixtures of coal slack and loam, clay or similar materials, has already been mentioned in the Introduction. The moulding of blocks naturally forms the basis of numerous experiments with the object of preparing better artificial fuels from small coal, in large quantities, for profitable and advantageous applications to industry.

These experiments took place partly at the end of the eighteenth but for the most part in the beginning of the nineteenth century, and though the object in view was not attained, they paved the way for the final successful solution of the problem.

Only the following need be mentioned here:—

1789. Chavanne[1] obtained an English patent for the preparation of pressed coals in the form of cakes. The sifted coal slack was intimately mixed with earth, clay, cow-dung, tar-pitch, broken glass, sulphur, sawdust, oil cake, tan, wood, or other vegetable matter, placed in water, dried in drained pits, and finally moulded into cakes of convenient size.

Some ten years later Weschniakow obtained a superior fuel—carbolein—consisting of 92 per cent. coal and 8 per cent. fat, by pressing a mixture of coal slack and animal fat between coarse hairy cloths, but the cost of the process was too high.

1832. E. Marsais of St Etienne patented a method of pressed-coal briquetting, using a mixture of coal tar and coal slack, but the briquettes were not strong enough.

[1] Knight, *The Practical Dictionary of Mechanics*, London. *Artificial Fuel*, p. 921. Preissig, *Die Presskohlen-Industrie*, Freiberg, 1887, p. 6.

1842. Marsais took out a patent for the application of soft coal-tar pitch (*brai gras*) as bond, and opened the first briquette factory at Bérard, near St Etienne. Four years later a second factory was opened at Givors.

1843. Wylam applied the use of hard coal-tar pitch in England.

This material at last provided the binder which rendered possible the preparation of pressed coals of superior quality on a manufacturing scale at a profit, providing the price of pitch were not too high. Pitch still maintains its supreme position as a binder in spite of repeated experiments to supersede it by other suitable and cheaper materials or by stronger compression, etc. (Further information on this point is given in Section II, "Briquetting Coals and Binding Materials.")

1848. H. Dobrée introduced in England the use of steam for heating the pressed coals made with tar in order to strengthen them, and to soften mixtures made with hard pitch previous to pressing. This has proved to be advantageous, and has since found fairly general application for this purpose.

After the establishment of the first briquette factory in France, similar factories were gradually opened out in other countries: in 1846 at Newcastle in England; 1852 at Montigny-sur-Sambre in Belgium; 1858 at Brandeisl near Prague in Austria, 1861 at Mulheim on the Ruhr in Prussia by the Zeche Vereinigte Wiesche.

The production of coal briquettes in the Western European countries rapidly assumed imposing proportions.

1867. There were already thirty-one factories in France, with a total production of over 1,000,000 tons of briquettes.

1869. Belgium possessed nine factories, with a yearly production of 515,000 tons, while England produced some 200,000 tons.

The total production of Europe amounted in 1880 to about 2,500,000 tons, according to Gurlt;[1] and in 1885 to about 3,900,000 tons, according to Preissig,[2] prepared in 120 to 130 factories, distributed somewhat as follows:—

France	1,300,000 tons.
Belgium	1,000,000 „
England	1,000,000 „
Spain	150,000 „

[1] Gurlt, p. 4. [2] Preissig, p. 19.

Italy	150,000 tons.
Germany	140,000 „
Russia and Sweden	100,000 „
Austria-Hungary, Netherlands, and Switzerland	60,000 „
Total	3,900,000 tons.

Of the countries outside Europe, the United States produced about 130,000 tons, to which must be added the production of some factories in Formosa, India, and Nova Scotia, so that the total world's production of coal briquettes must have been over 4,000,000 tons at that time.

Compared with its Western neighbours, a strikingly small share fell to the German Empire, although its coal production of over 57,000,000 tons in 1885 far exceeded that of France and Belgium (19,500,000 and 18,000,000 million tons respectively), and large quantities of coal slack, which might well have been briquetted, were produced. The high prices of pitch ruling in Germany at that time, and the keen competition in the ordinary coal trade, were the principal reasons why briquetting was not carried on to a much greater extent. The first German briquette factory (already mentioned), built by the Vereinigte Wiesche Mining Co. at Muhlheim on the Ruhr, was closed down in 1867. In the same year a new factory with plant and machinery was established by the Consolidated Mining Co. at Gelsenkirchen, but it soon failed. Up to 1880 only three factories continued to exist: the Zwickau Steinkohlenbauverein at Zwickau in Saxony, a plant at the Krupp works, Essen, and one at the Neu-Lauweg pit near Aachen (since 1875).

Shortly afterwards the following factories were established:—

A pit at Stockheim in Bavaria.

1881 and 1882. { Zeche Verein Dahlhauser Tiefbau.
Zeche Rhein-Elbe at Gelsenkirchen.
Zeche Franziska Tiefbau at Witten
Zeche Honigsborn at Unna.
Zeche Blankenburg at Blankenstein
Zeche Caroline at Holzwickede. } In Westphalia.

V. Kraustache Mine at Altwasser in Lower Silesia.

Max Meinert in Nieder-Schonweide at Berlin.

The last seven plants were equipped by the Couffinhal system (St Etienne), which had been acquired by the Schuchtermann &

Kremer Machine Co. of Dortmund. The same firm retained licenses for the plant and machinery for all the new factories opened in Germany after that time as well as for many plants abroad.

1884. The Karl Moritz Mine at Plotz (Halle district) opened.

1885. A factory was organised by the Zeche Ver. Bommerbanker Tiefbau in Westphalia.

The further development of the German coal-briquetting industry became very much more rapid. The principal centre of the industry still remains in the Lower Rhenish Westphalian coal-field (Dortmund Mining Commission).

The establishment of the Briquette Selling Syndicate at Dortmund in 1890, to deal with the bulk and later with almost the whole of the above-mentioned briquetting companies, was of the greatest importance in the development of the industry.

At the end of 1903 the sale of coal and coke was taken over by the Rhenish Westphalia Coal Syndicate

In 1907 the production of briquettes in the area of the Dortmund Mining Commission reached over 3,000,000 tons, and that of the German Empire over 4,000,000, or more than double the output of Belgium, France, and Great Britain. The development of the output of coal briquettes in the chief centres of the German Empire and in other important countries can be seen from the Briquette Statistics in Part I., Section XI., at the end of which the total world's production of briquettes for the year 1907 is estimated by the author to be 11,000,000 tons Since Preissig's estimate of 4,000,000 tons for 1885, the output has therefore been almost tripled in twenty-two years.

B. PROPERTIES AND APPLICATION OF COAL BRIQUETTES.

The essential properties of fuel briquettes of every description have already been dealt with in the Introduction (p. xxi) Of good coal briquettes the following requirements are specially demanded :—

(*a*) The shape, size, and weight of the blocks must be adapted to their special destination, *i.e.* to the nature and duration of the transport or storage, as well as to the manner of their use.

(*b*) Their strength (degree of cohesion) shall be at least equal to that of good coal, the loss by attrition and crumbling during ordinary handling and transport must not exceed 5 per cent.

(c) Their mean specific gravity (density) shall not be below 1·19.

(d) The ash must not exceed 10 per cent.

(e) They must not contain over 5 per cent. of water, nor absorb water, and they must not fall to pieces on long standing in water.

(f) Their calorific value (evaporative power) must be at least equal to that of a good coal.

In the written specifications of authorities and other large buyers, these requirements are sometimes more sharply defined or even made more severe in respect of one or other of the points. The Prussian railway authorities recently issued a statement in which their demands

FIG. 3.—Coal briquettes of various shapes and sizes.

were couched in a few appropriate words. With regard to the various requirements, the following points are to be noticed:—

(a) *Shape, Size, and Weight* (see figs. 3 to 7).—The shape and size of the blocks are of supreme importance, in order that the pressed coals may compete successfully with the natural coals. The great superiority of briquetting lies in the possibility of the production of every shape and form best adapted to the manner of application, and the special circumstances under which they have to be transported, stored, and fired. In addition, due regard must be paid to the economy of briquetting. In Germany, the railways, which use about 50 per cent of the total output, the navy and commercial marine, including the oversea export, the internal navigation, industries, and finally, households to which briquette firing has been applied, are to be regarded as the chief purchasers.

Briquettes intended for use on railways are usually first despatched to their destinations, stored in open regular heaps where they are often exposed under severe conditions to the action of wind and weather

until they are finally disposed of by loading into tenders for use in firing locomotives.

In the interest of the final object—rapid and complete combustion with maximum heating effect—large pieces are not advantageous, since they present far too little surface to the furnace atmosphere. Consequently, it would appear that small briquettes of cubical or preferably spheroidal shape would be most efficacious; they could be shovelled on to the grate without further trouble and would lie in juxtaposition with relatively few points of surface contact, thus

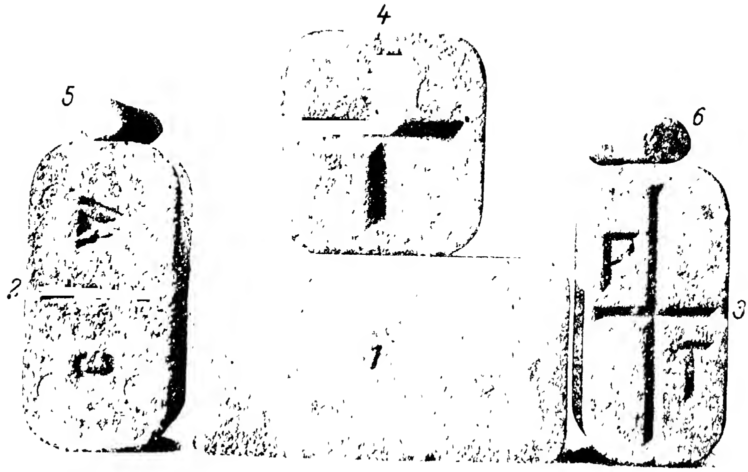


FIG. 1.—Coal briquettes of various shape and size.
(From the Briquette Collection of the Kgl. Bergakademie, Berlin.)

securing a ready, uniform admission and circulation of air. These small forms, however, have the disadvantages of not completely using the coal-storage space of the tender, are not adapted to storage in the confined space of coal bunkers at railway stations, nor to prolonged standing in the open, since, in consequence of the interspaces formed in storing, the rolling tendency, and the numerous edges and angles (particularly in prisms), they require a relatively large space, produce much slack by crumbling, and in time lose strength and heating power under the influence of atmospheric conditions, to which they are particularly susceptible.

The railway authorities have therefore for a long time past demanded medium-sized and easily handled briquettes of parallelepipedic shapes with rounded edges somewhat similar to good pieces of

coal. These conform in the highest degree to the special conditions demanded for railway work, their only disadvantage being that they require breaking before charging on to the grate, thus producing pieces of irregular size and troublesome slack which is not so conducive to successful firing as the use of small spheroidal or cubical briquettes. This disadvantage is, however, tolerated in view of the other superior properties of these large forms, furthermore, briquettes are used on locomotives chiefly in admixture with ordinary coals.

Briquettes of the following shapes and weights are used on the German railways.—

(*a*) *Elongated, brick-shaped*, 220 × 110 × 105 mm Weight about 3 kg. (Fig. 4, Nos 2 and 3; fig. 5, Nos 3 and 4)

(*b*) *Quadratic, flattened, cube-shaped*, 160 × 160 × 105 mm. (fig. 4, No. 4); also tall cubes 160 × 130 × 135 mm. Weight about 3 kg.

(*c*) *Elongated, brick shaped*, 280 × 150 × 110 mm (fig. 4, No. 1, and fig. 5, No. 2), also cubical, 185 × 185 × 135, or 200 × 150 × 155. Weight about 5 kg.

The (*a*) variety is most supplied inland, then the (*b*) variety, while the heavy variety (*c*) is prepared in much smaller quantities for export.

Smaller blocks 110 × 110 × 155 mm., of about 2 kg weight (fig. 6, Nos. 2 and 3), are also compressed, *e.g.* for the Royal Saxon State railways.

In Belgium, briquettes of 4 kg. and in England of 9 lb. weight (about 4 kg) are supplied to the railways.

As will be seen by the illustrations, in addition to the maker's mark (the initial letter of the mining company or factory), one or more grooves, which sometimes cross, are pressed into the upper face of most of the larger bricks. These grooves form planes of least resistance, and serve for splitting and dividing the blocks into approximately equal pieces with the least possible trouble. This is best done by hammering a broad flat chisel or an iron wedge inserted into the groove, whereby the pieces can be broken off to the desired extent. With a little practice it is possible to break up the required number of briquettes rapidly, without making an undue amount of smalls.

In dealing with the supplies for marine steamships and oversea export, it is essential that the more or less limited storage space of the ship should be utilised in full, so that the greatest possible stock of high-valued fuels can be stored up under such conditions that they will not suffer much damage up to the time of their use nor by the

rolling and vibrations of the ship during oversea transport, nor by exposure to the high temperatures of the southern seas.

Of the various fuels, parallelepipedic-shaped coal briquettes seem to be the most adapted to these special demands, since the total length of the easily crumbled sharp edges and the surface exposed to rubbing is

FIG. 5.—Coal briquettes of various size and shape (1–10). Hard pitch (11) and resin (12) in pieces.
(From the Briquette Collection of the Kgl. Bergakademie, Berlin.)

small compared with the total contents. It could be said that the larger the blocks the better, but this is not quite true, since when they exceed a certain weight they become too heavy for convenient handling. Further, such large briquettes are not so easily obtained with the necessary density and strength as the small ones. The largest briquettes are prepared in England, where blocks up to 28 lb. weight are compressed for export to the West and East Indies (12·7 kg.)—a weight which roughly corresponds to the burden of a native.

The next largest are made in Germany, briquettes of 11 kg. weight being supplied to the navy. Fig 5, No. 1, represents such a briquette of 300 × 220 × 125 mm. dimensions. It will be seen that in the interest of packing in the smallest possible compass, the short edges are rounded at a considerably smaller radius than those of the accompanying medium-sized blocks. A new form of 10 kg. weight measures 300 × 200 × 125 mm. For the same object there are prepared:—

In Hungary, 10 kg briquettes	. .	280 × 189 × 147 mm.
„ France, 9 „		
„ Belgium, 8 „	. .	220 × 200 × 160 „

In inland steamship navigation the conditions are much more favourable to the briquettes, since the rolling and vibrations of the ship have disappeared The shipping companies therefore generally favour the larger medium blocks of 4–6 kg, which, in comparison with the heavier naval briquettes, present the advantage of easier handling, and on the other hand allow of closer packing and give less waste than the railway briquettes.

The 5-kg briquettes described under (*c*) (fig. 5, No. 2, F M) and the somewhat rarer forms

5·3 to 5·8 kg { 275 × 150 × 100 mm., or
240 × 160 × 120 mm., or
300 × 150 × 105 mm, as well as
6 kg. and 260 × 160 × 135 mm.,

are German brands.

Of the foreign brands the above are very similar to the pressed coals of 5·6 to 5·8 kgs and 230 × 154 × 130 mm. made near Hong-Kong.

In the use of briquettes in manufacturing and industrial processes such as the heating of boilers, etc., the problem lies in the immediate consumption of the selected fuel to obtain the highest possible heating effect or evaporative power under conditions favouring the development of such special properties as "long flaming," etc., rather than in the necessity for long-distance transport by rail or ship and in the prolonged close confinement of stores in cramped spaces or in the open, although such conditions may occur, in which case the choice of the coal is made in accordance with the principles already laid down. The kinds of briquettes preferred for such purposes are the small rounded or cubical pieces which show decided advantages over the larger forms, and up to the present no considerations similar to those previously discussed have been adduced to make the choice of railway or other

large briquettes preferable. Of course, it must be observed that where small briquettes are advantageous, their introduction is rendered difficult because of the competition with natural coals in the form of sieved and washed cubes and nuts. This is the principal reason why the preparation of small briquettes for industrial purposes from coal dust has not attained much importance up to the present, although the manufacture of so-called "egg briquettes" by means of roll presses is fairly old. In the Lower Rhenish Westphalia district such

FIG. 6.—Coal briquettes of various size for locomotive firing (1–3), and for house fuels (4–8)
(From the Briquette Collection of the Kgl. Bergakademie, Berlin.)

briquettes are made in weights of 135, 130, 125, 65, and 35 grams, in a few factories at the present time, not so much for boiler heating as for house fuels (see below) and for oversea export, for which purpose they are put into sacks of a capacity corresponding to a convenient load. The three latter sizes of egg briquettes are shown in fig. 11, Nos. 9 and 10, and in fig. 7, as they would lie on a grate.

Of late, small cubical briquettes with slightly rounded edges have been made by the toggle-joint and revolving presses of the Tigler-Surman and Yeadon systems, *e.g.*:

Cubes of	220	grm. and	60 × 60 × 48	mm.
„	115	„ „	48 × 48 × 39	„
„	105	„ „	50 × 50 × 33	„

Two samples of the two latter varieties are shown in figs. 5 and 6, Nos. 7 and 8. However, still smaller blocks even down to below 80 grams weight are moulded.

These cubical briquettes are of considerable density and strength, but their preparation on a manufacturing scale is attended by not inconsiderable difficulties. The use of coal briquettes as domestic fuels is largely influenced by the competition with natural coal. The public at large is very conservative with regard to fuel for grates and for the heating of rooms, and, if accustomed to the use of coal as fuel, will only forsake it with reluctance. The advantages to be derived from the use of briquettes in this direction are very much under-

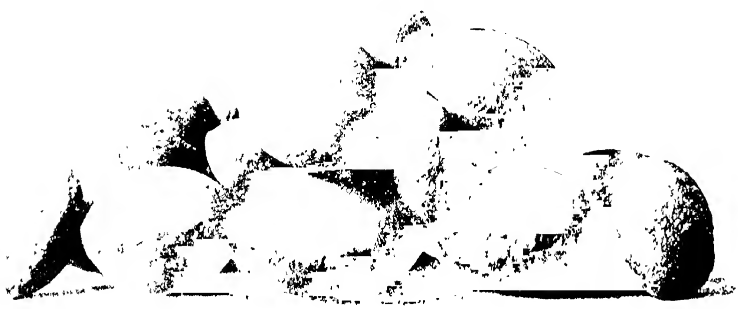


FIG. 7.—Egg briquettes of various sizes
(From the Briquette Collection of the Kgl. Bergakademie, Berlin.)

estimated and very little appreciated. In the Central German towns which are further removed from the coal-mining districts of the east and west, but lie more or less close to the brown-coal regions, all the advantages of brown-coal briquettes, which compared with coals recommend themselves by a much lower price, have been known and valued for a long time, in fact, it has already been mentioned in the Introduction that by far the greatest proportion of the total brown-coal briquette production of Germany is used for domestic fuels.

Uniform shape and size of the briquettes permits of a simple and sure regulation and control of the delivery and uses: the briquettes can be ordered by number, the correct delivery checked by counting, the exact number assigned to the various grates according to the heat required, and in fact all arrangements can be carried out and the

remaining stock determined by counting. A pleasant feature of briquettes for domestic applications is that they only slightly discolour and neither soil nor become dusty, not to mention their other advantages.

The same applies to coal briquettes. Naturally, only easily handled briquettes are applicable as house fuels for domestic purposes, and preferably only such as can be applied directly without previous breaking. The nature of the heating appliances really determines their shape and size. Formerly, perforated coal bricks (fig. 8) found great favour in France for burning in open grates. Every brick was bored with seven holes of 10 mm. diameter. This increased the surface exposed to the air and resulted in a much more lively combustion. The rapid wear of the pegs used to produce the holes during pressing has resulted in a considerable falling off in the production of such briquettes during late years. The blocks of almost cylindrical shape shown at the right of fig 3 and in fig. 4, Nos. 5 and 6, are now scarcely ever prepared The brands of house fuel now manufactured for heating ordinary stoves appear to be the large cubical briquettes of 220 grm. (see above), and especially the blocks of the dimensions

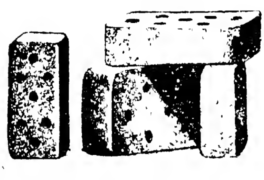


FIG. 8.—Perforated coal briquette.

350 grm	and	$70 \times 70 \times 65$ mm.		
500 ,,	,,	$80 \times 80 \times 65$	,,	
750 ,,	,,	$70 \times 70 \times 135$	,,	(fig. 6, Nos 4–6)
1 kg.	,,	$80 \times 80 \times 135$	,,	
$1\frac{1}{4}$,,	,,	$90 \times 90 \times 135$	,,	

prepared in rotating presses, as well as the small brick-shaped briquettes of 1 kg. and $170 \times 85 \times 50$ mm (fig 5, No 5) suitable for the purpose of covering ordinary coal fires.

The small industrial cubes and "egg" briquettes are well adapted for the heating of American stoves and slow-combustion stoves for which purpose anthracite nuts were previously greatly favoured, and, as a result, modern American briquetting practice is applied in the direction of manufacturing egg briquettes and similar forms for this purpose.

The medium sized briquettes for household purposes are only sold in limited quantities to small purchasers living in the neighbourhood

of the briquette factory. These are either the ordinary 3-kg. brick briquettes of the above measurements or—

Brick briquettes of	3 kg.	and	225 × 110 × 90 mm.
„ „	„ 2·5 „	„	220 × 110 × 90 „
Quadratic „	„ 2·5 „	„	140 × 140 × 100 „

(*b*) *Strength of Briquettes.* A high degree of cohesion is one of the most valuable properties of good briquettes. It determines their strength, adaptability to transport and storage, and to a large degree their superiority over and ability to compete with natural coals. The cohesion, or the tendency of the particles of a solid body to hold fast together must, in the case of briquettes, be at least as great as in a piece of the constituent coal, and in fact the higher it is the better.

The internal cohesion of various coals has been determined by experiments made on similar samples under definite conditions[1] and expressed as percentages by weight of the sample taken. In the following table the mean values, together with the highest and lowest figures, of the cohesion of a number of home and foreign coals and briquettes are collected from the results of a long series of experiments made at the Kaiserlichen Werft at Wilhelmshaven from 1874 to 1st October 1886,[2] as well as from other sources.

[1] The comparative tests made at the Kaiserlichen Werft in Wilhelmshaven to determine the degree of cohesion were conducted as follows. The coals or briquettes to be tested were broken into pieces of 0·2 to 0·5 kg. weight, and were sieved on a 30 mm. sq. meshed sieve 1·75 m. long by 1 m. wide, inclined at 40° in such a way that the whole of the material was charged on to the upper end of the sieve and caused to roll down its whole length. Fifty kg. of the pieces freed from dust were placed in a sheet-iron cylinder 1·15 m. long and 0·85 m. diameter, provided with a hopper for introducing the material. Internally three ribs 0·16 m. high were attached to the periphery, and the cylinder was mounted on trunnions and had a winch, by means of which the cylinder was rotated slowly fifty times in about two minutes after the coal had been introduced and the cylinder closed. After this treatment more or less "fines" were produced according to the strength of the coal, and removed by sieving through the previously described sieve. The pieces which did not fall through the meshes were collected, and their total weight, expressed as a percentage of the 50 kg. originally taken, gives a figure representing the cohesion. The experiment was usually repeated three times, and the mean of the most closely agreeing determinations taken.

The French navy worked under similar conditions, except that the sheet-iron drum was 1 m. long × 0·92 m. diameter, the three radial ribs 0·23 m. high, and the coal to be tested used in pieces of 0·5 kg. weight. (Preissig, p. 35.)

[2] See "Collection of the Comparative Experiments on the Calorific Value and other technically Important Properties of Various Kinds of Coal," *Marine-Verordnungsblatt*, Appendix to No. 19, 1876, and Appendix to No. 23, 1886; reproduced in *Z. f. B.-, H.- u. S.W.*, vol. xxv. p. 64, 1877, and vol. xxxv. p. 169, 1887.

Source or Kind of Coal.	No.	Average Degree of Cohesion.	Highest Degree of Cohesion.	Lowest Degree of Cohesion.	Remarks.
I. German Coals.					
		per cent.	per cent	per cent	
Upper Silesia	10	81·11	86·87	52·20	According to the Wilhelmshaven experiments.
Lower Silesia . . .	23	76·74	90·30	57·95	
Lower Rhenish Westphalia	232	52·71	88·93	28·04	
and (*a*) Gas coals . .	55	73·48	88·93	52·26	
(*b*) Fat coals . .	165	46·37	86·50	28·01	
(*c*) ,, . . .	12	44·60	51·64	37·36	
Aachen . . .	3	60·23	64·00	58·20	
II. Foreign Coals.					
		per cent.	per cent	per cent.	
England and Scotland	10	58·05	82·47	13·98	
especially (*a*) Cardiff (S. Wales)		∼45	47	42	From other sources.[1]
(*b*) Newcastle . .		∼55	60	50	
Anzin (Pas de Calais)	...	∼30	35	24	
III. German Briquettes.					
		per cent	per cent	per cent	
Lower Rhenish Westphalia . .	23	53·31	73·00	34·70	Wilhelmshaven experiments.
,, .	3	61·49	63·73	59·13	

From this table it appears that the Lower Rhenish Westphalia briquettes, with 53·31 per cent., show a somewhat higher average degree of cohesion than all the natural coals (52·71 per cent.) from this district, further, that their cohesion is some 6 to 8 per cent. greater than that of the fat, hard, and smithy coals (46·37–44·60 per cent.) which are almost exclusively employed for briquetting. Of the Wurm district coals and briquettes the latter again show a somewhat higher cohesion.

According to Colquhoun,[2] the degree of cohesion of good briquettes should generally reach 55 per cent. The French navy demands at least 52 per cent.

The strength and durability of briquettes depend upon a variety of factors: the nature of the coal used, the binding material, the degree of fineness, moisture, the proportion and intimacy of admixture of the two constituents, the temperature and length of heating before pressing, and the nature and magnitude of the applied pressure. Briquettes of correct composition and method of preparation ring hard like clinker briquettes, show sharp edges when freshly pressed in the prismatic form, crumble only to a very limited extent under the ordinary methods

[1] William Colquhoun, *Briquette Manufacture.* Gluckauf, Essen, 1894, p. 1795.
[2] Gluckauf, 1894, p. 1795.

of handling, transport, and storing, giving at the most only 5 per cent. waste in the form of dust, and resist weathering to a very high degree. The latter property depends upon the fact that in good briquettes almost every individual particle of coal is surrounded by pitch, and is in this way protected against the action of air and moisture.

(c) *The Density or Specific Gravity* (weight of 1 c.cm. in grm.) of good briquettes made with coal-tar pitch is almost equal to the density of the natural coals from which they are prepared: this varies between 1·2 and 1·4, the average being 1·3.

A specific gravity below 1·19 results from insufficient pressing; a high density indicates a high content of ash, since the foreign matter accompanying coal (shale, etc.) is specifically about twice as heavy (2·7).

For parallelepipedic briquettes, whose approximate volumes can be determined by multiplying together the length, breadth, and height, making corresponding deductions for the rounding of the edges and impressions, the density can be calculated from the formula

$$\delta = \frac{G}{V} \text{ or density} = \frac{\text{absolute weight}}{\text{volume}}$$

by weighing the brick and dividing the weight by its volume.

(d) *The Ash Content*[1] of briquettes is somewhat lower than that of the coal used in cases where the binding material is purely organic, such as hard pitch, resin, etc. In other cases the ash is more or less increased by the non-combustible constituent of the binder. A very low content of ash is especially important for briquettes which have to be used or carried long distances oversea in steamships. In pressed coals for application nearer the neighbourhood of the centre of production, however, a somewhat higher ash content, or the use of an inorganic binding material, can be allowed. It is usually advisable to wash impure coals before briquetting, since in this way the ash content can be diminished to between 9 and 5 per cent. The average ash content of briquettes amounts to about 7 per cent. Twenty-three brands of Lower Rhenish Westphalia briquettes tested at Wilhelmshaven in the years 1876–86 showed an average content of 6·87 per cent., while three briquettes from the Wurm district showed 6·73 per cent. Briquettes containing more than 10 per cent. ash are generally of too little value for consideration.

(e) *The Water Content*[2] can be traced partly to the natural moisture

[1] For the determination of ash, see Junemann, *Die Brikettindustrie und die Brennmaterialen*, ii. Aufl., 1903, p. 185.

[2] For the determination of water, see Junemann, *l.c.*, p. 182.

of the coal (mine moisture), partly to the "watering" process used in the mine to prevent the dangers arising from coal dust, partly to the water used in the coal washing, and also to the condensation of part of the steam led into the mixture of coal and pitch immediately before pressing in the ordinary briquetting practice. The amount of pit moisture arising from the so-called water fermentation is generally determined by the geological age of the coal The older a fossil fuel the less water it contains when fresh According to Brockmann,[1] the proportion of moisture in the coals of Rhineland and Westphalia is about as follows.—

Gas flaming coals	up to	4	per cent	H_2O.
Gas coals	"	3	"	"
Coking coals	"	2	"	"
Splint coals	"	1	"	"
Anthracite	"	½	"	"

The tendency of dried fuels to reabsorb moisture (hygroscopy) depends upon the geological age or the fermentation epoch and the chemical composition. A geologically young coal is always more hygroscopic than an older one Since the oldest coals splint, forge, and coking coals are subjected to briquetting, the mine moisture is of secondary importance in determining the moisture content of the briquettes. The influence of watering and the later introduction of steam is also of little importance, but the water remaining from subterranean sources and from the washing process is of much greater moment. A high content of water is a disadvantage, since, in briquetting with hard pitch, it renders the internal binding and the application of powerful pressure difficult, thereby making the addition of larger quantities of the expensive binding material necessary and diminishing the calorific value and adaptability to storage of the prepared blocks Consequently, there is every reason for suitably drying moist coals before mixing. According to Colquhoun, the average water content of briquettes is 3 per cent.

(*f*) *The Calorific Value* of briquettes must be at least as high as that of the coal briquetted; as a result of the addition of pitch, it is usually somewhat higher than that of the crude coal. If the elementary composition of a fuel (in this case a briquette) has been determined by chemical analysis, its theoretical calorific value—*i.e.* the total heat

[1] *Die Entwickelung des Niederrheinisch-Westfalischen Steinkohlenbergbaues in der zweiten Halfte des 19. Jahrhunderts*, 1903, vol. i. p. 260.

generated on complete combustion—can be calculated by means of Dulong's well-known formula:—

$$A_{HU} = \frac{8100C + 34{,}500(H - \frac{1}{8}O) + 2200S - 600W}{100}.$$

The heat unit (H.U.) or calorie used as a measure of the quantity of heat is the amount of heat necessary to raise the temperature of 1 kg. of water 1° C.

As determined directly by numerous experiments, there are developed by the combustion of

1 kg. pure carbon to carbon dioxide	.	8,100 calories.
1 „ „ hydrogen to steam	. .	34,500 „
1 „ „ sulphur to sulphur dioxide	.	2,200 „

To convert 1 kg. of water at 0° C. to steam at 100° C., 637 calories are necessary; this figure is usually taken roundly as 600.

The theoretical calorific value is calculated by multiplying the percentage of carbon by 8100, the available hydrogen $(H - \frac{1}{8}O)$ by 34,500, the volatile sulphur by 2200, and finding the sum of the products. This figure is diminished by 600 × the sum of the hygroscopic and chemically combined water, since this water is evaporated during the combustion, for which purpose a certain amount of heat is necessary and decreases the heat of combustion developed. Finally, the figure is divided by 100, because percentages have been dealt with.

The accuracy of Dulong's formula has, however, often been contested on various plausible grounds. In any case, it is advisable to make use of an approved and relatively accurate calorimetric method, *i.e.* to measure the quantity of heat evolved during combustion directly by means of a calorimeter, for the determination of the theoretical heating effect of a fuel.

Berthelot's calorimeter finds most favour in laboratories, experimental stations, and with boiler-inspection associations.

A sample (about 1 grm.) of the fuel to be tested is introduced into a completely closed combustion chamber—the calorimetric bomb—and completely burnt in a few seconds in an atmosphere of oxygen at about 25 atmospheres pressure, the rise of temperature of a known quantity of water surrounding the combustion chamber being observed. From this, the number of units of heat given by the fuel can be calculated by means of a comparatively simple formula. This figure, calculated to 1 kg. of the fuel, gives the "heating value."

The latter is defined as follows in § 13 of "Normen fur Leistungsversuche an Dampfkesseln" (rules for testing steam boilers):—

The heating value is estimated on 1 kg. of the original coal without allowing for ash, moisture, etc. The calculation is made under the assumption that the hydrogen in the fuel is burnt to steam, and that the moisture remains in the form of vapour. Consequently, the following points must be considered[1]:—Liquid water is obtained as a final product in the combustion of coal in a calorimeter; the bomb stands in water at 15–20° C., so that the water formed by the combustion of the coal condenses to the liquid form on its inner walls The number of units of heat referring to liquid water is known as the heat of combustion, and this figure is used only in scientific experiments.

In order to obtain the "heating value," the heat of evaporation of the water formed must always be subtracted, because in the application of fuels for heating, the hot gases are in every case taken away at so high a temperature that the water formed remains in the state of vapour. Consequently, it is incorrect and liable to lead to error to describe the "heat of combustion" as the "heating value" or "upper heating value," as is often done in certificates recommending the use of certain coals or brands of briquettes.

For the practical purposes of heating it is impossible to apply the whole of the heat of combustion The various modern calorimeters of Mahler, Hempel, Krocker,[2] and others depend upon the same principle and are generally to be regarded as variations or improvements of Berthelot's arrangement.

Calorimetric measurements of various kinds of coal made in the laboratory of the Magdeburger Vereins fur Dampfkesselbetrieb in the years 1896–1899 gave the following results[3] —

Variety of Coal tested	No. of Tests	Mean Heating Effect (Cals.) determined calorimetrically
Westphalia coal . .	42	About 7820
Silesian ,, . .	7	,, 6910
Saxon ,, . .	8	,, 6310
English ,, . .	22	,, 6870
Bohemian ,, .	4	,, 4700

[1] H. Langbein, "Heizwert oder Verbrennungswarme?" *Z. Braunkohle*, 1902, No. 39, pp. 465–467 ; *Z. f. angewandte Chemie*, 1900, p 1235.

[2] "Kalorimeter nach Berthelot-Mahler mit abgeanderter Einrichtung der Verbrennungsbombe nach System Dr H. Krocker," *Z. f. B.-, H.- u. S W.*, i Pr. St, 1901, Bd. 49, p. 349. Graefe, "Kalorimetrische Untersuchungen von Kohlen," *Z. Braunkohle*, 1904, No. 10, pp. 121–123. Graefe, "Aus der Praxis der Kohlenanalyse," *ebenda*, 1904, No. 18, pp. 237–243, mit Abb. u. Beschreibung der Hempelschen Bombe.

[3] *Z. des Ver. Deutsch. Ing.*, 1899, No. 12 ; and Glückauf, 1899, p. 404.

Below some further calorimetric determinations of the heating values of certain coals and briquettes from Lower Rhenish Westphalia are given:—

	Average Chemical Composition.		Heat Units per kg. (determined in Calorimeter).	Remarks.
Washed fat coal nuts from the Carl shaft of the Kolner Mining Co., Altenessen.[1]	Carbon	per cent 80·9	7823 ± 57	Determined in the laboratory of the Mining Co. at Bochum and in the laboratory of the Magdeburger Vereins fur Dampfkesselbetrieb, in 1900.
	Hydrogen	4·65		
	Oxygen	6		
	Ash	1		
	Water	2		
Briquettes of splint and non caking coal from the Wilhelm shaft of the Gewerkshaft Victoria at Kupferdreh.[2]	...		7407	
Briquettes of splint and smithy coal of the Zeche Dahlhauser Tiefbau.[3]	Carbon	83·21	7816	
	Hydrogen	4·05		
	Oxygen and nitrogen	3·13		
	Sulphur	1·26		
	Ash	7·26		
	Water	1·06		

The following list of heating values of various natural and artificial fuels (sawdust, brown coal, and coal briquettes, according to H. Langbein),[4] are of special interest:—

Fuel.	Heating Value in Cals.
Sawdust briquettes	3,400– 4,100
Turf (air-dried)	2,700– 4,800
Soft brown coal (moist from mine)	1,900– 3,100
Brown-coal briquettes	4,600– 5,400
Bohemian brown coal	3,600– 5,500
Silesian coal	5,300– 7,500
Saxon coal	5,400– 7,200
Westphalia coal	6,600– 7,900
English coal	6,000– 7,800
Coal briquettes	6,100– 7,700
Anthracite	7,600– 8,500
Paraffin oil	9,800– 9,840
Petroleum	10,300–10,330

[1] Gluckauf, 1901, p. 165.
[2] Gluckauf, 1913, pp 1214–1215.
[3] Gluckauf, 1906, No. 31.
[4] From Polster's *Kalender fur Kohleninteressenten*, vol. iv., 1904.

Next to the theoretical calorific value of a fuel or the number of calories of heat contained in 1 kg, the number of kg. of water at 0° C. which can be converted into steam at 100° C. by 1 kg. of the fuel is of great importance in judging its value.

The evaporative power can only be determined by evaporation experiments. The results for one and the same fuel will vary with the arrangements used, the boiler system, the construction of the whole boiler plant, and the method of conducting the experiments. Comparative experiments with different fuels must therefore be made in one and the same evaporation plant by methods similar to those generally employed, as is always done at the Kaiserlichen Werft zu Wilhelmshaven.[1] In the following table the results obtained for the evaporative powers of Lower Rhenish Westphalian and Aachen coals and briquettes at the latter institution during the years 1874–1886 are shown, the calculated mean values together with the highest and lowest figures being given —

Brand of Coal tested		Water at 0° C. evaporated by 1 kg. Coal or Briquette		
District of Origin and Kind of Coal.	No	Mean kg	Highest kg.	Lowest kg.
I. Coals				
Lower Rhenish Westphalia	216	8 196	9 277	6·199
(a) Gas coal	57	7 512	8·295	6·199
(b) Fat coal	171	8 444	9 277	6 936
(c) Non caking and splint coal	15	7 913	8 517	7·029
Aachen Wurm district (flaming and splint coal)	3	8 643	8 776	8 582
England and Scotland	10	7·980	8·569	6·888
II. Briquettes				
Lower Rhenish Westphalia	23	8 635	9 164	7 030
Aachen Wurm district	3	8 383	8·661	8·155

From this table it will be seen that the mean evaporative power of the Lower Rhenish Westphalia briquettes tested (8 635 kg.) exceeds that of the whole of the coals tested from that district by 0·439 kg., the gas coals by 1·123 kg., the fat coals by 0 191 kg., and the forge and splint coals by 0 732 kg.—a striking testimony in favour of the briquettes.

Later, Wilhelmshaven[2] experiments have given the following results

[1] See the description of the testing plant and methods in *Marine-Verordnungsblatt*, Beilage zu No. 19, 1876, and *Z. f. B.-, H.- u. S. W.*, vol. xxv., 1877, pp. 64 and 75.

[2] *Z. f. Dampfkessel- und Maschinenwesen*, 1908, No. 12, pp. 112–113; and *Stahl und Eisen*, 1908, No. 26, p. 899.

for the evaporative powers of coal briquettes from Westphalia and the Wurm district:—

Mining Co.'s Briquettes.	Kgs. Steam produced by 1 kg. of Briquette.
Frie Vogel und Unverhofft .	8·20
Victor	8·83
Dahlhauser Tiefbau .	8·02–9·02
Herkules	8·42–9·02
Siebenplaneten . .	8·22–9·19
Neu-Iserlohn . . .	8·30–9·75
Briquettes from the Wurm district	6·93–8·66

With regard to the behaviour of coal briquettes in the fire, it is to be remarked that well-prepared briquettes made with pitch as binding material generally ignite easily and burn regularly with a lively flame without crumbling and giving off much smoke. Their behaviour depends especially on the properties of the constituents, the amount and degree of fineness of the pitch, upon the way in which the briquettes are made, and upon the shape and size of the briquettes or pieces of briquettes which are charged on the fire. Briquettes of very splinty anthracite coal- or coke-dust ignite with greater difficulty than those prepared from coal containing more gas, and are not so stable in the fire, since the pitch melts and runs away or burns more rapidly than the anthracite particles. In order to avoid this, it has now become general to mix anthracite or coke slack with a certain quantity of more bituminous coal, fat coal or fat-flaming coal being the best, which has at the same time the advantage of decreasing the amount of expensive pitch necessary. Small briquettes ignite more easily and burn more rapidly than larger ones, since they expose a greater surface. Rough fractured surfaces are more favourable to ignition than smooth pressed surfaces. Large and medium-sized briquettes are consequently, especially at the beginning of firing and when rapid steam generation is required, broken into suitable-sized pieces (1–1½ kg.) before use (see above, p. 7). When the fire is fully alight large unbroken briquettes can be charged.

With briquettes made from splint and semi-fat coals it is advisable not to poke the fire. On the other hand, it is necessary to stir up the fire now and then when fat-coal briquettes are used, because of the caking properties of the fat-coal particles. The development of smoke[1] is usually less in the case of briquettes than with the natural coals.

[1] Polster's *Kalender fur Kohlenindustrie*, 1904, p. 125.

It is recommended that in attending to the fires care should be taken to lay the briquettes close to the furnace opening at first, when the smoke evolved during ignition passes through the whole of the flame and is largely consumed. The development of smoke has been observed during the experiments carried out by the Kaiserlichen Werft zu Wilhelmshaven because this is of great importance in naval ships. The pressed coals from the Wurm district and from Lower Rhenish Westphalia, tested in the period from 1874 to October 1886, showed that only—

1	brand	of	briquettes	evolved	dense black smoke.
2	brands	„	„	„	semi-dense dark grey smoke.
2	„	„	„	„	transparent grey or brownish smoke.
6	„	„	„	„	still lighter grey or brownish smoke.
12	„	„	„	„	thin, scarcely visible smoke.
4	„	„	„	„	no, or almost no, smoke.

The latter brands included briquettes from the coal boundary of the Wurm district. During the combustion of untreated coals from the same sources a not inconsiderable development of smoke lasting 8–12 minutes was observed. This favourable behaviour of good briquettes can probably be traced to the fact that they are of uniform density, and that the combustion is promoted by the uniform and slow distillation of the pitch which assists ignition.[1] In this connection coal briquettes appear to be specially adapted for the requirements of the navy. Chemical methods for the examination of coal briquettes have been dealt with by E. J. Constam and R. Rougeot in Zurich.[2] Special importance is attached to the treatment with carbon disulphide in which good pitch is for the most part soluble. In briquettes the content of matter soluble in carbon disulphide should be not less than 5 per cent., while the content of volatile constituents should be not less than 16 per cent.

[1] *Z. f. B.-, H.- u. S.W.*, vol. l., 1902, p. 212.
[2] Gluckauf, Essen, 1906, No. 15, pp. 481–493.

SECTION II.

THE BRIQUETTING COALS AND BINDING MATERIALS.

A. BRIQUETTING COALS.

ALTHOUGH all kinds of coal can be rendered amenable to briquetting by the addition of a more or less suitable binding material, only certain varieties are briquetted to any considerable extent in practice.

In Lower Rhenish Westphalia which is by far the most important coal-briquetting centre of Germany, the following general conditions prevail.

Since there is usually a market for lumps and mixed coals of every description, only small coals come into consideration for briquetting.

1. Gas-flaming and gas coals are used least of all.
2. Fat coals come next.
3. Semi-fat or fat-flaming coals are more frequently used.
4. Smithy and hard coals are used most of all.

1. The gas-flaming and gas coals from the upper portion of the carboniferous formation in the above district are distinguished by special hardness and cohesion (see the table on p. 14), their degree of cohesion being, on the average, over 50 per cent. The small coal not used for home consumption generally finds a good sale in industrial and manufacturing undertakings such as brick-kilns, lime-kilns, illuminating gas manufacture, etc. Consequently, although the material is well adapted to successful briquetting, it is usually only applied under special conditions, namely, as an addition to the small hard coals.

2 and 3. The fat and semi-fat coals are not so coherent, their cohesion being often under 40 per cent., and the enormous quantities of slack and dust produced are for the most part coked. Otherwise they are briquetted, especially where there is a poor sale for coke. The amount used reaches about 20–25 per cent. of the total coal briquetted,

requires the least addition of binding material, and yields briquettes of the highest calorific value.

4. The smithy and hard coals form the greatest proportion of the coals briquetted (about 70–80 per cent.), and their degree of cohesion usually falls below 40 per cent. Formerly there was no adequate outlet for the slack and dust which were continually produced in large quantities, and for the most part lay in the mining companies' yards as a valueless waste product. The introduction of briquetting was a solution of the problem, and was at once applied to the greater part of these small coals When this is not done with the whole output it has of late become possible to burn fine coals on a special grate with an undercurrent of air (Kudliez system of firing, etc.) with advantage.

The result is that a not inconsiderable part of the small smithy and hard coal is now used at the mine itself and in the neighbouring industrial plants for the heating of boilers, etc. In recent times another method of utilising especially the splinty anthracitic coals has been discovered, namely, the combustion in so-called generators with the object of preparing a cheap heating or power gas (producer gas) used directly for driving gas engines which in turn serve more particularly to drive dynamos.

This extraordinarily important modern development has, however, done very little injury to coal briquetting Hard coal and anthracitic slack are only very slightly adapted to briquetting by themselves or even with the addition of hard pitch alone as binding material. Satisfactory results can, however, be obtained by mixing such materials with a more or less caking coal, by mixing lime or some other suitable material with the pitch, or by using a binding material of quite a different nature.

In the United States of America several briquette factories have recently been established on the Atlantic coast to deal entirely with Pennsylvania anthracite slack with, according to report, the best of results. In view of the enormous quantities of fine coal and dust produced yearly at the Pennsylvania pits by the crushing machinery,[1] its appreciation in value as a result of briquetting is of the utmost importance. Coke slack behaves like anthracite slack. Further information on the varieties of coal briquetted in the various coal districts is given in Section XI., "Coal-briquetting Statistics"

[1] Klose, "Die Aufbereitung der Steinkohlen in den Vereinigten Staaten von Nordamerika," *Z. f. B.-, H.- u. S.W.*, vol. xlii., 1894, p. 119.

The Preparation of Coal for Briquetting.—*General.*—The grains of coal slack and dust used for briquetting vary from 11 or 10 to 0 mm. in size, are of various shapes—almost cubical, laminated, splintery, granular, etc.—and are frequently more or less impure owing to the admixture of particles of useless stone, such as shale, sandstone, bituminous schist, pyrites from the mine, the associated strata and debris from the coal beds.

Small coal of such a nature is, however, not suitable for briquetting, but requires a further preliminary wet or dry preparation which has two distinct objects in view:

(1) Removal of the admixed impurities as far as possible.

(2) Breaking up of the coarse coal particles and complete mixing of the fine coal with the coal dust.

The preparation is either carried out in both directions when the coal smalls—preferably after previously blowing away the dust—are first washed, then dried, and finally reduced to the necessary state of division and mixed, or subjected to the last operation only. The purer the fine coal used for briquetting, the less ash there is in the briquettes obtained, and at the same time the greater the calorific value and similar properties (as already laid down on p. 15 *et seq.*) compared with those of the coals. On the other hand, care must be taken, particularly with the finest of coals, that the wet separation of the impurities, especially the particles of mine clay, does not lead to considerable difficulties in view of the adhesive tendencies of the latter, and lead to expense as regards plant and maintenance which could easily have been saved. Washing is consequently omitted on principle when the small coal contains only a moderate amount of ash (8%–10%), and is usually discontinued when the ash content is a few per cent. higher. However, small coals containing over 12 per cent. of ash are invariably subjected to a preliminary washing if they are intended for briquetting.

In England coal washing is not general, and is carried out at a few plants only. Only the purer sorts of riddled coals containing less than 10 per cent. of ash are briquetted.

With regard to the fineness and degree of admixture of the briquetting coal, it must be remarked that the presence of a certain amount of dust, distributed as uniformly as possible amongst the somewhat coarser grains of coal, is absolutely essential to the production of dense strong briquettes; on the other hand, coals consisting wholly of dust can only be briquetted with a disproportionately large amount of binding material. The higher the content of dust the greater the

surface of the coal particles exposed and the greater the amount of pitch required to ensure solidity.

Wet Preparation of Coals.—In the ordinary wet methods of dressing, coals broken to below 80 mm. are first sorted into four classes of nuts between 80 and 10 mm. and fine coal of below 10 mm. by means of rocking table sieves or revolving drum sieves. They are then further worked up on an equal number of coarse-grain settling machines; the fine coals being treated in a fine-grain settling machine whose comparatively large-meshed sheet sieve is covered with a settling bed 8 to 10 mm. thick made of Norwegian granite or coarse slates. In the rear portion of every settling machine the settling water is depressed and allowed to rise again in rapid succession either by a piston driven rapidly to and fro from an eccentric rod or—in the Baum-Herne system—by a current of low-pressure air introduced in a fine stream and allowed to escape. By this means the reverse motion is communicated to the water in the earlier settling tanks on the principle of the communicating tubes. When elevated the water lifts the bed of felspar or slate from the sieve, through which it rushes and washes the impure small coal by carrying the lighter particles higher than the gangue. When the water falls the particles of gangue sink lower and lower with each stroke until they finally fall through the sieve into the lower settling tanks, where they are removed by a worm conveyor or by some other means. The coal particles are lifted higher and higher with each stroke until they reach the surface and are removed by the overflow of water.

In the modern Baum[1] system of washing, which is already in use at a number of works, treatment is carried out in accordance with the maxim "First wash, then classify." The whole of the coal delivered (80 to 0 mm.) before sorting into nuts and small coal is placed in a bed settling machine (driven by compressed air) and freed of gangue. Only after this are the wet-washed coals separated into the various-sized nuts and fine coals by means of a classifying drum. This procedure presents many important advantages, which cannot be further discussed here, but still leaves something to be desired in respect of the purity of the product. As a result, an after-treatment of the fine coal in a special sorting machine becomes necessary. In well-conducted and careful coal washing it is usually possible to reduce the content of gangue or ash to below 9 to 5 per cent., and in some cases even lower. The cost of washing is about 20 to 30 pfgs. (2½d. to 3½d.) per ton.

[1] Gluckauf, 1902, pp. 668–669, and plate lxxxi., figs. 6 and 7

The Dehydration of Washed Coals.—Washed coals require a certain amount of drying before the final crushing and mixing. This can often be done simply by allowing the coals to stand in wooden boxes. After twenty-four hours' standing fine coals under 9 mm. in size will lose 12 to 25 per cent. water. If after such treatment the moisture content is still 10 to 12 per cent., centrifugal machinery can be advantageously applied for further drying.

In the Dortmund Mining Commission district the complete practical dehydration of washed fine coal is now often effected in masonry drying towers built with pockets and provided with filters (Schüchtermann & Kremer, Dortmund), in large iron storage and drying towers almost closed below and fitted with a central tubular sieve (Baum, Herne), in the drying towers of the Humboldt Engineering Co. of Kalk, or on endless sieve like drying belts which travel very slowly (Baum, Humboldt).

The Eisenwerke Gerlach & Co. use either masonry drying towers through which chain-band conveyors pass, or their recently patented centrifugal drying apparatus,[1] for dehydrating washed small coals and slimes. Such an apparatus consists of an enclosed vertical screw caused to rotate rapidly. By means of a horizontal screw the wet small coal is delivered on to the lowest turn, thrown against the cover, gradually carried upwards from turn to turn, and delivered at the top, dry. The lower part of the cover is provided with sieve openings.

In this way, as in the centrifugal machines used in sugar and salt factories, etc., a large quantity of the water is thrown out. The residual water is further brought to evaporation as above, and removed by suction through holes in the screw shaft. To hasten the evaporation the cover is built with a double wall so that it can be steam-heated. The material to be dried has to travel a long way on the spiral in spite of its rapid movement. In a normal apparatus of 5 m. in height, 1 m. in breadth, and 70 cm between each turn, the distance amounts to 78 m. This adequately explains the efficiency of drying effected by centrifugalising. Such an apparatus will deal with 10 tons per hour. Further advantages gained are as follows:—Considerably more rapid and better dehydration than is obtained with the drying towers, and at the same time less power is consumed (∼ 2 H.P.) and the depreciation is lower.

One of the most modern and best organised systems of coal washing in a briquette factory (at the Hagenbeck Mining Co., built by

[1] Glückauf, 1902, p. 669, and plate lxxxv. fig. 1.

Schüchtermann & Kremer) is illustrated and described in Section XI., "Complete Coal Briquette Manufactories."

B. BINDING MATERIALS.[1]

General.—It has already been pointed out in the Introduction that a special binding material is indispensable for the preparation of briquettes on a manufacturing scale The bituminous matter in non-anthracitic coals only begins to soften and form a sort of binding material at high temperatures As a result, the pressure must be increased to such an extent that the work becomes unprofitable. Any possible heating of the mass during compression by means of special appliances leads to other difficulties, *e.g.* the press is strongly attacked by the heating arrangements, and the workers suffer from the great heat and the noxious vapours

Since the very early days of the pressed-coal industry a large number of different materials have been applied, or at least proposed, for "binders" on the experimental or manufacturing scale Although coal-tar pitch (*brai*) and, after pitch, a certain kind of resin, have for a long time been recognised by both theory and practice to be the best and most generally adaptable and are, as a matter of fact, used almost solely (seldom with any addition), the efforts to find another binding material have not been abandoned up to the present. The grounds for this lie principally in the prices of pitch and resin, which, in spite of quite considerable fluctuations in different years, always rule very high, and at the present time have become very costly. Since the economical value of coal briquetting is largely determined by the expenditure on binding materials, the search for a cheaper material appears to be explained and justified.

Moreover, the search affects the binding material for anthracite or coke slack, flue dust or ore slimes, etc., for the briquetting of which coal-tar pitch or resin is not suitable without the admixture of other materials.

Binding materials can be divided into organic and inorganic substances and substances of organic or inorganic origin.

Organic materials possess the great advantage that they themselves burn and contribute to the heat generated, whilst inorganic materials are incombustible, absorb heat, and increase the content of ash. Accordingly, inorganic substances cannot really be regarded as binding

[1] Preissig, 1887, p. 69. Steger, "Bindemittel fur Brennstoffbriketts," *Z. f. B.-, H.- u. S.-W.*, vol. 1., 1902, p. 311.

materials. The fact is, they are used only in small quantities as additions to organic substances, and recommend themselves because of a low price as well as by exercising a useful action in some direction or the other.

In every case the following is expected of the binding material:—

(1) That it permits of the preparation of briquettes which conform to the specifications already laid down (compare pages xxv and 4).

(2) That it can be obtained in large quantities of uniform quality at such a price that the costs of the necessary amount, together with the costs of incorporating it, leave a moderate profit

With regard to (1) it is to be remarked that the minor properties of the briquettes, especially a somewhat higher content of water or ash, can as a rule only be taken into account on buying, in the case of industrial briquettes which are to be used in the neighbourhood of the centres of production without long storage In the following pages the two approved organic binding materials, pitch and resin, are first dealt with, especially with regard to their properties, testing, and application, the other organic, the inorganic, and compound binding materials being subsequently more or less shortly described

I. Pitch (F. brai, Ger Das Steinkohlenpech).

When coal is subjected to dry distillation, gas, tar, and ammonia liquor are obtained as distillates, while coke remains as a residue. The pitch is obtained from the tar

Coal tar[1] (*goudron de houille, Steinkohlenteer*) is a more or less dark-coloured, oily, usually viscous mass of peculiar smell, it consists principally of hydrocarbons, but contains in addition other neutral, acid, and basic bodies.

The proportion of the constituents depends on the composition of the coal and the conditions of the distillation, particularly on the temperature, mode of action of the heat, and the size and shape of the distillation vessel. Tar was formerly only obtained as a bye-product in the manufacture of illuminating gas, the coking of coal, the working of certain metallurgical blast-furnaces fed with raw coal, and in the manufacture of producer, oil, and water gases.

By far the largest quantities of tar have always been obtained in the manufacture of illuminating gas.[2] The distillate evolved from the retorts consists of ammonia liquor, tar, and gas A large part of the tar and ammonia liquor condenses in the trough-shaped vessel half filled with water attached to

[1] Bornstein in Dammer's *Handbuch der chemischen Technologie*, vol. iv., 1898, p. 430.
[2] *Ibid.*, vol. iv., 1898, p. 230.

the furnace cover and connected with the retort by means of a tube which dips under the surface of the liquid, the remaining tar, carried away from the traps by the gases at 50°–100° C., is collected in the coolers (condensers) and the scrubbers which serve to purify the gas. According to Schultz, of 100 parts of the tar obtained from English coal, there is found about 61·6 per cent. in the traps, 11·8 per cent. in the coolers, and 26·8 per cent. in the scrubbers. In a similar manner tar is obtained in the modern coking plants, such as the Otto-Hoffmann and other systems, which are provided with appliances for the separation of the bye-products, tar and ammonia liquor, and are often equipped for the further treatment of these materials, such as the preparation of the various tar distillates—benzol, pitch, and ammonium sulphate. The manufacture of these bye products has already attained considerable magnitude in Germany, principally in Lower Rhenish Westphalia, Upper and Lower Silesia.

Blast-furnace tar is recovered almost solely in the west of Scotland, where bituminous coals (splint coals) are still used direct instead of coke. The tar collects chiefly in the flue gas mains. Similarly, tar occurs in producer-gas mains and elsewhere.

The latter sources of tar are of quite secondary importance compared with the two first named. The yield of tar depends upon the temperature of distillation as well as upon the properties of the coal, and is generally greater the more uniform the heating and the lower the temperature. In the manufacture of illuminating gas it amounts to between 3·5 and 6·75 per cent., and in coke manufacture between 2 and 6 per cent.

Coal Tar as Binding Material.—It has already been mentioned in Section I. that crude coal tar has been used as a binding material in the oldest briquette factories, yet it is very little adapted for the purpose, since it becomes sticky, softens too easily, and only burns with a troublesome development of smoke, accompanied by a peculiarly unpleasant odour. Experiments with the object of making briquettes prepared with tar more useful and adaptable to despatch by thorough drying have led to no successful results, consequently the practical application of crude tar has for a long time past been almost completely abandoned. According to Colquhoun,[1] it has been used only as an addition to pitch for the last ninety years in Central France, where, in distinction to the general practice of using solid pulverised pitch (*brai*) for briquetting, the pitch is used in the liquid form usually mixed with 15 per cent. crude tar, and in the La Chazotte works of the Paris-Lyon Railway with 30 per cent.

Tar has, however, gained an extraordinary importance in the

[1] Gluckauf, 1894, p. 1795.

briquetting industry in another way: it forms the starting-point for the preparation of pitch, which is the most important and practically the only binding material for the briquetting of coal slack.

Pitch is almost wholly obtained from coal tar In addition, the tar obtained from brown coal, peat, or bituminous schist, which forms the basis of the mineral and paraffin-oil industries of Western Europe, must be considered as well as wood tar, the tar obtained from petroleum residues, and so on. On the other hand, increasing quantities of pitch have recently been obtained from natural asphalt (asphalt pitch) in North America, and sulphite cellulose residues (cell pitch) in Germany, all of which varieties find application as binding materials. (For further information see below)

Coal-tar pitch is the residue left after distilling tar to a certain degree. The distillation is effected, after previous dehydration, in cylindrical wrought-iron distilling vessels, which are heated over an open fire or by the introduction of superheated steam. By "fractionation," *i.e.* slowly raising the temperature and interrupting the distillation at definite temperatures, gas tar yields, according to Muck :—

Up to 140° C.—light oils (benzol, toluol, and homologues).
„ 220° C.—light and heavy oils (higher homologues of benzol, naphthalene, and carbolic acid).
„ 300° C.—heavy oils (naphthalene and carbolic acid).
300 to 400° C.—anthracene (with phenanthrene and higher homologues of benzol).

According to Lunge —
Up to 105 or 110° C.—light runnings ("light naphtha," essence).
„ „ 210° C.—light oil
„ „ 240° C.—carbolic oil (phenol and naphthalene).
„ „ 270° C.—heavy oil.
Above 270° C.—anthracene oil.

In another factory —
Up to 165 or 170° C.—light oil.
„ „ 230° C.—medium oil
„ „ 270° C.—heavy oil
Above 270° C.—anthracene oil.

According to Sadter-Bornemann —
First the "runnings" with a specific gravity of 0·78 to 0·85.
Up to 210° C.—light oil „ „ „ 0·83 to 0·89.

From 210° to 400°—heavy oil which sinks in water, and
Up to 300° C.—creosote oil.
From 300° to 400° C.—anthracene oil.

Coke-oven tar generally gives similar results on distillation. According as the distillation is discontinued early or late, at a medium or high temperature, one or other of the following kinds of pitch is obtained as residue:—

Asphalt (*brai liquide*, very viscous after cooling) when the light oil is evolved and the distillate has the density of water, *i.e.* 1.

Soft pitch (*brai gras*, *Weichpech*) when about half the heavy oil is removed and the distillate has attained a density of about 1·09

Semi-soft or medium hard pitch (*brai demi sec*) when the heavy oil and the first anthracene oil is driven off and the density of the distillate is 1·09 to 1·12

Hard pitch (*brai sec*, *Hartpech*) when the anthracene oil is almost completely driven off at 400° C. At first quite liquid, it is carefully cooled in the pitch chamber and poured into open moulds or vessels where it solidifies to a black shining mass.

The following table by Kohler[1] illustrates how the magnitude of the individual fractions, or the quantities of the various distillates and residues, vary with the origin of the tar or coal and with the nature of the distillation:—

	German Tar.	South German Tar	North German Tar	Paris Tar	English Tar	London Tar	London Tar.	Lancashire Tar.
	per cent.	per cent.	per cent.	per cent	per cent	per cent.	per cent.	per cent.
Ammonia liquor	...	2·5	5·6		4·0	1·6	2·00	2·2
First runnings .	5–8	3·0	2·6	1·8–2·0	1·5	1·5	1·66	2·2
Light oil . .		8·0	2·8		1·5	1·16	1·62	10·6
Carbolic oil .	25–30		4·5	21–26	22·0	11·16	15·70	
Creosote oil .		15·5	15·5					7·6
Anthracene oil	8–10	10·0	9·5	9·5–10·0	1·0	15·8	20·73	16·9
Pitch . .	50–55	60·0	56·0	65–66	67·0	60·0	56·29	60·5
Loss . .		1·0	2·5	...		2·78	2·00	...

The following genealogical tree[2] shows diagrammatically the derivation of the various tar products as well as the uses to which they are applied.

The following table[3] shows how greatly the production of tar, thick tar, and pitch developed during the years 1903 to 1907 in the

[1] H. Kohler, *Steinkohlenteer*, Breslau, 1893, p. 33.

[2] From a special exhibit at the Dusseldorf Exhibition, 1902, by the Konig Ludwig Mining Co. at Recklinghausen, Lorraine at Bochum, and Friedrich der Grosse at Herne.

[3] "Die Bergwerke und Salinen des Oberbergamtsbezirks Dortmund in 1907," pp. 9–10 (Appendix to Gluckauf, vol. ii., 1908).

FIG. 9. Genealogical tree of coal tar products and their applications.

district of the Dortmund Mining Commission as a result of th increased recovery of the coking by-products:—

	1903.	1904.	1905.	1906.	1907.
	Production of Tar.				
	tons.	tons.	tons.	tons.	tons.
Dortmund Mining Commission's district .	133,915	188,580	241,756	328,790	381,97
	Thick Tar.				
" " "	...	215	536	606	627
	Tar-Pitch.				
Mining district:—					
Dortmund II.	67	48	140	165	45
" III.	1,110	3,439	4,239	4,628	4,183
Ost-Recklinghausen	4,221	5,305	6,985	8,980	12,075
Witten	20	23	14	30	1
Nord Bochum	3,005	3,607	3,534	5,706	6,920
Herne	2 622	3 733	4,555	5,869	5,876
Gelsenkirchen	1,094	1,128	1,930	7,781	10,032
Wattenscheid	3,712	3,723	5,132	5,890	5,698
Ost-Essen	82	51	62	102	171
West Essen	2,064	10,171	10,581	13,537	13,876
Oberhausen	19	20	26	8	18
Duisburg	602	431	575	...	...
Dortmund Mining Commission's district .	18,948	31,679	40,773	52,696	58,885

The artificial asphalt prepared from tar, which stands in close relationship to the varieties of pitch employed, is scarcely so good a binding material. Only the true pitches, from soft pitch to hard pitch are generally applied in briquetting.

Nowadays in tar distillation the tar is but seldom distilled to soft or semi-soft pitch, a more usual practice when a softer pitch is required being to complete the distillation and to mix the residual hard pitch with certain other tar products. According to Lunge,[1] this so-called "reviving of the pitch" is usually effected with the heavy oil or naphthalene or the tar which has been freed of light oils (asphalt), 10 to 20 parts of these materials being added to 100 parts pitch. Lubricating oil free from anthracene would also appear to be suitable.

The preparation of revived pitch is carried out by melting the hard pitch with the selected addition in vessels heated with superheated steam and provided with double-walled spiral-stirring appliance, or by pumping the oil into the hot pitch.

By varying the composition of the mixture and suitably adjusting the operations it is possible to prepare one or the other variety of pitch, either having the properties of a true soft pitch or medium hard pitch, or to prepare an intermediate product partaking more of the nature of a hard or soft pitch as required.

[1] Lunge, *Die Industrie des Steinkohlenteers und Ammoniaks*, Braunschweig, 1888.

Properties and Testing of Pitch.—According to Habets, good hard pitch has the following average chemical composition:—

75·32 per cent. carbon.	8·19 per cent. hydrogen.	= 100·00
16·06 „ „ oxygen.	0·43 „ „ ash.	per cent.

Lunge states that it always contains small quantities of the least volatile constituents of coal-tar oil, such as anthracene, phenanthrene, pyrene, chrysene, etc., in addition to certain not very well-defined substances such as bituminous materials, and it may also contain free carbon.

Its specific gravity lies between 1·275 and 1·286. It forms a black glistening mass which is very brittle and breaks with a conchoidal fracture (see above, fig. 5, No. 11). The dust from hard pitch causes an unpleasant burning of the face and attacks the eyes.

Hard pitch	softens at 100° C.	and melts between 200° and 150° C.
Medium-hard pitch	„ „ 70°–50°	„ „ „ 100° „ 80° C.
Soft pitch	„ „ 40° C.	„ „ „ 60° C.

The softer pitches are generally a deeper black in colour and possess a more brilliant lustre than hard pitch, this becoming more and more pronounced as the softness increases. At the same time, the deleterious effect on the eyes decreases.

The testing of pitch is usually directed towards the determination of

(*a*) The degree of hardness and adhesiveness.

(*b*) The softening temperature.

(*c*) The melting-point.

Under certain conditions it is also advisable to determine

(*d*) The quantity and nature of the residue left on coking.

(*e*) The chemical properties and the calorific value.

(*a*) Hardness and adhesiveness are determined in a very simple manner by means of a chewing test in which small pieces of the pitch are brought between the teeth and the tongue.

Hard pitch is quite unaffected by the heat of the mouth and remains brittle; on chewing it is reduced to a powder with a grating noise.

Medium-hard pitch is less brittle, gives a little under the teeth, but can only be chewed with difficulty.

Soft pitch can be chewed with ease.

With a little practice the adhesiveness can be estimated with sufficient accuracy by means of the above test. It does not depend

altogether on the hardness; but appears to be more intimately bound up with the quality of the pitch.

(*b*) For the accurate determination of the softening temperature the method applied by Dr Muck in a large number of pitch tests at the Bochum mining laboratory can be recommended.[1]

From the sample of pitch to be tested cylindrical rods, 4 mm. diameter by 100 mm. long, were prepared. At one end 20 mm. were bent round and fastened by means of a rubber ring to the bulb of a thermometer in such a way that the long arm was parallel to the thermometer stem. The whole was then immersed in a beaker of water provided with a stirrer and gradually heated up until the long arm of the test piece bent over.

A simpler method which has been recently applied consists in heating a sample of the pitch in a small vessel until threads can be drawn from it by means of a thermometer.

The softening temperature will naturally depend very largely on the degree of hardness as determined by the chewing test.

(*c*) An accurate determination of the melting-point can be made in Lunge's apparatus by a method which finds considerable application in France.[2]

A sheet metal cylinder carries a horizontal dividing wall into which are soldered five tubes closed at their bottoms. The central tube serves for the introduction of a thermometer, while samples of ground and sieved pitch are placed in the other four. Both the dust and the coarse particles must be removed by sieving from the sample to be tested. The pitch powder is loaded with an iron disc and pointer of known weight. Water is now poured into the cylinder until the tubes are covered, and the whole is heated by means of a burner until the discs sink into the pitch, and the temperature at which this occurs is noted as the melting point of the pitch.

(*d*) While Muck[3] considers that the quantity of residue left by pitch on coking is of no importance in briquetting, Constam and Rougeot[4] consider it to be of some note, and state that it should never exceed 45 per cent. The form and nature of the coke is, however, of special importance, since this gives a true indication of the mechanical process taking place when the briquettes prepared with pitch are heated. This mechanical process is exactly the same as that occurring when a bituminous coal or similar substance is heated in such a manner as to undergo decomposition and leave behind a solid residue.

The material concerned—be it coal or pitch—either becomes very fluid

[1] F. Muck, "Ueber die Werthbestimmung von Theerpech (hart) als Bindemittel für Briketts" (*Z. f. B.-, H.- u. S.-W.*, vol. xxxvii., 1889, p. 371).

[2] Dammer's *Handbuch der chemischen Technologie*, 1898, iv. p. 477.

[3] F. Muck, *Z. f. B.-, H.- u. S.-W.*, vol. xxxvii., 1889.

[4] Gluckauf, 1901, No. 15, pp. 481–493.

and permits of the ready evolution of gases and vapours without puffing out the liquid mass (as with a sintering gas coal) or the fused mass is very viscous and becomes blown out by the escaping volatile constituents leaving behind a very porous residue (as with a caking coal).

Very similar phenomena are observed with many pitches, and according to Muck the crumbling of certain briquettes made from hard coals is due to nothing but bursting brought about by the inflation of the pitch, which only becomes very viscous after fusion.

The coking test is carried out by the method introduced by Muck[1] for the testing of pit coal.

1 gram of the finely powdered coal is placed in a weighed platinum crucible (at least 3 cm. high) closed with a tightly fitting lid and heated over a simple bunsen flame (18 cm high) until no more volatile constituents issue from between the lid and the crucible. After cooling the crucible is again weighed, and the weight of the residue represents the coke

In the following table are accumulated the results of pitch tests carried out by Dr Muck in the Bochum laboratory. Almost the whole of the samples were obtained from Westphalian briquette factories, and were representative of those varieties of pitch in actual use, or intended for use in the district. The results are arranged as far as possible in the order of the softening temperatures.

No.	Degree of Hardness as determined by the "Chewing Test"	Softening Temperature °C.	Residue on Coking		Origin of the Pitches tested.
			Per cent.	Nature	
1	Hard	110	58·50	Not pulled	The pitches marked * were blast-furnace pitches, while the remainder were from gas tars or coke-oven tars
2*	Very hard	over 100	50·09	Apparently pulled	
3*	Hard	100	36·61	Pulled	
4*	,,	50	38·31	,,	
5*	Fairly hard	49–52	32·91	,,	
6*	,, ,,	50	32·93	,,	
7	Medium soft	50	58·89	Sintered	
8*	Hard	50	35·49	Pulled	
9	Fairly hard	45–47	47·27	Sintered	
10	Medium hard	47	38·05	,,	
11	,, soft	46	45·40	,,	
12	,, ,,	45	46·98	,,	
13	,, ,,	42–45	51·19	,,	
14	Soft	40–42	47·36	,,	
15	Very soft	42	33·71	,,	
16	,, ,,	43	37·54	,,	
17	Fairly soft	43	49·75	,,	
18	,, ,,	36–38	33·42	,,	
19	Medium soft	36	41·34	,,	
20	Very soft	35	43·92	,,	
21	,, ,,	35	54·97	,,	
22	,, ,,	33	45·33	,,	
23*	Soft	32	30·22	Pulled	
24	Very soft	31	33·97	Sintered	

[1] Muck, *Chemie der Steinkohlen* (2nd ed., Leipzig, 1891), also Dammer's *Handbook*, p. 54.

From this table it appears that towards the end of 1880 soft and medium-soft pitches were preferred at the Westphalian briquette factories. Further, the whole of these pitches, with the single exception of No. 23, gave a sintered residue on coking, whereas almost the whole of the hard pitches, along with soft pitch No. 23, gave puffed residues. The striking fact that all the pitches with a puffed residue were blast-furnace pitches is also of considerable importance. These pitches originated from deposits in the gas-mains of coal-fired metallurgical furnaces, and must therefore be of quite a different nature from the gas- or coke oven tar-pitch.

In his remarks on the table Muck called special attention to the fact that briquettes which were designated by the producers as "not standing well in the fire" had been produced with pitches which in every case had given a puffed coking residue, while on the other hand the good briquettes had been produced exclusively from pitches which gave a sintered residue and originated from gas- or coke oven tar.

On the whole, the samples of pitch of approximately equal softening temperatures show quite considerable variations with regard to their degree of hardness and the quantity of residue left on coking. This can well be ascribed to the different sources of the pitch (from gas- or coke-oven tar) or of the materials used for reviving.

From what has already been said, backed up by the results of recent tests and practical experience, the much-discussed question as to which variety of pitch is the best for briquetting finds its solution in the reply that sintering pitch is better than a puffed pitch, and therefore that gas- or coke-oven tar-pitch possesses decided advantages over blast-furnace pitch.

With regard to hardness, softening temperature, and adhesiveness, current practice in many countries, and more particularly in Germany and England, has determined on the use of medium-soft or soft pitch softening at temperatures between 70° and 40° C. Pitch softening at lower temperatures (down to 30° C.) is, on account of difficulties in transport and pulverising, only applied in the cooler seasons, when it is called "winter pitch", or it may be mixed with the coal in the molten state.

In warmer climates, and especially in France, Belgium, Hungary, and Hong-Kong, hard pitch has been almost exclusively applied since the seventies.

The softer pitches possess the following advantages over the harder varieties:—

1. Much less dust is produced during crushing.
2. The dust does not produce the same deleterious effects
3. A much smaller quantity of heat is required to soften the material sufficiently to produce a plastic mixture of the coal and pitch.

The price of the pitch can also become a determining factor in the selection, so that a somewhat less adhesive pitch which will work well can be applied if it can be obtained at a low price.

(e) With regard to the chemical behaviour, Constam and Rougeot[1] state that the solubility in carbon disulphide is of the greatest importance. It should be not less than 70 per cent. Further, the hydrogen content of a good pitch must not rise over 5 per cent., and the calorific value should be not less than 8550 cals.

Amount of Pitch added.—Using pitch alone as the bond, the amount required to effect a good and lasting adhesion between the particles of coal varies between 5 and 10 per cent and usually between 6·5 and 9 per cent. This means that 6·5 to 9 parts of pitch must be added to 93·5 to 91 parts of the coal to be briquetted. Generally speaking, the pitch addition becomes greater

as the hardness of the coal increases,	as the admixture of the coal and pitch becomes more irregular, and
as the proportion of coal dust increases,	as the compression pressure decreases.
as the moisture in the coal increases,	

These conditions have already been referred to above in their proper places. At this point it is only necessary to make special reference to the fact that coal slimes from clarifying pits, which by themselves would require an addition of at least 20 per cent. of pitch in order to attain sufficient strength, can only be briquetted in admixture with well-dried small coal.

Briquetting material of normal composition requires an addition of not more than 9 per cent of pitch in order to attain its full strength, which is not materially added to by further additions. With less than 5 per cent of pitch, consolidation of the small coal cannot as a rule be obtained.

The following figures show the average amounts of pitch added in the various countries and districts:—

England	8 to 10 per cent.	Saxony	5 to 7 per cent.
Continent of Europe	5 ,, 9 ,,	Lower Silesia	6·5 ,, 7 ,,
Northern France and Belgium	6·3 to 8 per cent	Upper Silesia	6·7 ,, 9 ,,
Lower Rhenish Westphalia	6·5 ,, 8 per cent	Hungary (Funfkirchen)	6 ,, 7 ,,
		Eastern Asia (Hong-Kong)	9 ,,

[1] Gluckauf, 1906, No. 15, pp. 481–493.

Cost of Pitch.—Pitch is a relatively dear material. Its cost to the briquette factories in the district of the Dortmund Board of Mines amounted to between 30 and 58 marks per ton for the years 1891-1903, even with the large amounts dealt with by the Dortmund Briquette Selling Agency. Since 1891 the duties of this Agency included the provision of its factories with the necessary and continually increasing amounts of high-quality pitch as punctually and as cheaply as possible.

The table below gives a review of the total briquette sales of the whole of the companies the quantity of pitch bought by the Agency, the amount of money paid for this material, and the approximate price per ton and also the average selling price per ton of briquettes in the years named.

Year	Total Briquette Sales of the whole of the Mines	The Dortmund Briquette Selling Agency.				
		Pitch Procured	Total Sum Paid for the Pitch	Approximate Price of Pitch per Ton (Free at Works)		Average Sale Price per Ton Briquette.
				at the Beginning of the Year	at the End of the Year	
		tons	marks	marks	marks	marks.
1891	182,495	20,821	926,535	44–48	44 45	12·67
1892	553,075	40,034	1,611,394	44–45	37 40	10·47
1893	694,020	53,584	1,973,685	37 40	37 39	9·08
1894	745,414	60,785	2,348,485	36 39	41 48 50	8·82
1895	796,363	59,032	2,657,716	45 50		9·07
1896	830,980	65,067	2,780,418	45	41	9·34
1897	913,732	70,631	2,467,566	40 40	31 60	9·99
1898	1,078,338	79,757	2,422,265	39 50	31	10·22
1899	1,295,113	103,185	3,523,515	32	36	10·66
1900	1,530,816	108,976	4,741,682	41	44	12·27
1901	1,563,928	116,956	5,013,211	42	44	13·33
1902	1,610,215	112,795	4,623,561	41	43	12·20
1903	1,780,390	113,923	6,386,589	53	58 50	11·47

According to the yearly reports of the Dortmund Briquette Selling Agency in Gluckauf. See also the tables on the output of coal and the production of coke and briquettes in the Dortmund district, and also the curves showing the principal results of the work of the Agency in Section II.

Among others, the following facts can be deduced from the table:—

In the interval between 1892 and 1902, in which the sales of briquettes[1] increased from 553,075 tons to 1,610,215 tons, the amount of pitch used by the works increased from 40,034 tons to 112,795 tons, *i.e.* the amount used has been almost trebled. Whilst, however, the briquette sales in 1902 (1,610,215 tons) as compared with the previous

[1] The briquette sales do not differ materially from the quantity made.

year (1,563,928 tons) had increased by 46,287 tons, or about 3 per cent., the amount of pitch used was 4161 tons, or 3·56 per cent. lower. Further, the briquette sales for the year 1903 (1,780,390 tons) showed an increase of 170,175 tons (equal to 10·57 per cent.) as compared with 1902, while the amount of pitch used (113,923 tons as against 112,795 tons) only increased by 1128 tons, equal to 1 per cent.

These important facts can be explained as follows:—

1. That under the pressure of the high price of pitch the Rhenish Westphalian briquette manufacturers have learned to improve the methods of working so as to permit the use of a smaller amount of pitch.
2. That many of the works have economised by substituting a portion of the pitch by resin or some other binding material (see below).

The table also shows how the yearly cost of pitch has reached the enormous amount of over 6 million marks, it shows that the price of pitch has been subject to considerable variations during the period from 1891 to 1903, *e.g.* in the short space of time from the beginning of 1899 to the end of 1900 the price of this material rose from 32 to 44 marks per ton, an increase of about 27·3 per cent., while in the same period the proceeds from the sale of the briquettes only rose from 10·66 to 12·27 marks per ton, an increase of only 15·1 per cent.

The year 1903 showed still less satisfactory results,[1] since pitch rapidly rose to a price it had scarcely ever reached before (for a time it reached 74–75 M per ton, free at works), and remained at an extraordinarily high figure until the end of the year. At the same time the average proceeds from the sale of the briquettes fell from 12·20 M. in 1902 to 11·47 M., a decrease of 6 per cent.

The cause of this enormous increase in price was a sudden scarcity of pitch in England, hitherto the principal source of supply, which coincided with an enormous increase of the briquette productions of Germany, France, and Belgium In the Dortmund district, however, under the guidance of the Essen Coal Syndicate, which took over the Briquette Selling Agency after 1903, success was attained in rendering the industry independent of the English pitch market. In the few years immediately previous to this time the production of tar as a bye-product of the local coking industry was so increased that the corresponding rise in the amount of coke-oven tar-pitch obtained made it possible to cover the requirements of the local briquette factories, with the result that the price of pitch automatically fell to its normal level.

[1] Glückauf, 1904, pp. 345–346.

The cost of pitch [1] (f.o.r. at the factory) amounted to:—

	1904.	1905.	1906.	1907.
	M	M.	M.	M.
At the beginning of the year.	50	41	40·50	40·50
At the end of the year.	49	38 50	40 50	39

During the above period the whole of the pitch requirements of the briquette factories of the district (over 187,000 tons in 1907) were covered by the local production

Upper and Lower Silesia are catered for by the bye-product recovery coking plants of Upper Silesia In 1907 the price of pitch in this area was 33 35 marks per ton, free at works.

II. Resin.

It has already been pointed out on p 40 that since the nineties many of the Lower Rhenish-Westphalian briquette factories have used a certain amount of resin with the pitch as binding material, particularly in times when the price of pitch was high [2] Resin forms the distillation residue of the production of turpentine from the American pines *Pinus australis* and *Pinus taeda*. It is hard, brittle, dark-brownish coloured material which breaks with a conchoidal fracture and is transparent only at the edges (see fig. 5, No. 12, p. 8). Its specific gravity averages 1 1, and its melting-point lies at about 120 C Consisting mainly of hydrocarbons, resin, like pitch, has a very high calorific value. It is, however, much more easily ignited than hard pitch, and cannot be added to the briquetting coal in processes using a heating oven with direct firing, for fear of fires.

Resin requires to be very finely powdered, its dust is very apt to cause inflammation of the throat.

Although it possesses a higher adhesive power than pitch, resin cannot be used by itself as a binding material The coal bricks and briquettes made at the Eiberg mine at Steele,[3] with resin as the sole binding material showed very little strength and soon fell to pieces in the fire. As soon as this occurred the resin rapidly burned away and left behind the not very readily combustible small coal. This crumbling in the fire is quite in accordance with the fact that in a platinum crucible resin gives a puffed coking residue, and it is to this expansion that the bursting of the briquette is due.

Further experiments have proved that resin can only be applied

[1] *Cf.* Section XI.: "Consumption of Briquetting Coal and Pitch."
[2] Glückauf, 1894, p. 1642. [3] *Z. f. B.- H.- u. S.-W.*, vol. xlii., 1894, pp. 235–236.

in very small quantities as an addition to pitch, which material cannot be dispensed with as the principal binding material. The resin is at least twice as dear as the pitch, but in spite of this an economic advantage can be obtained by its use on account of its greater binding power making the use of a smaller amount possible

Assuming that in the sole use of pitch an addition of 7 per cent. of the briquetting mass is necessary, then by the use of a mixture, 4 per cent pitch plus 1 per cent. of resin will give the same binding effect.

At a price of 40 M per ton for the pitch and 80 M per ton for the resin, free at works, the cost of the binding material per ton in the two cases works out as follows

(a) using pitch alone $\frac{7 \times 40}{100}$ 2.8 M

(b) using pitch + resin $\frac{4 \times 40 + 1 \times 80}{100}$ 2.4 M,

so that in case (b) a saving of 40 pf per ton of briquettes is effected. If the yearly output is 30,000 tons, for example, the economy obtained amounts to 12,000 marks

By the application of pitch at 35 M per ton and resin at 80 M. the economy effected by using the above mixture is only 5 pf per ton, or 1500 marks per annum, while with pitch at 40 M and resin at 85 M. per ton there is a loss of about 5 pf per ton of briquettes produced.

At many briquette factories results cannot be obtained with 4 per cent pitch and 1 per cent resin, in these cases it is much more usual to employ 5 per cent pitch and 1 or 0.5 per cent of resin according to the special circumstances

In 1903, as a result of a scarcity of pitch and the consequent extraordinary high price of this material, the use of resin considerably increased in the Dortmund district and reached 3000 tons With the return of pitch to its normal price the use of resin again disappeared

For the time the necessary amount of resin was obtained by the Briquette Selling Agency in barrels of 120 kgs from North America.

III. Other Organic Binding Materials.

In addition to the above-mentioned materials, many other organic substances have been experimented with or proposed as bonds, either alone or in admixture with inorganic products. However, most of them have proved unsuitable on some grounds or other, and only very few of them have ever been applied on a working scale. It is nevertheless quite possible that a few of the more recently proposed materials

have not been tested sufficiently, and that they may be called upon to play a certain part in the future development of the industry.

Of such organic substances only the following will be recognised here :—

Naphthalene.	Wine lees residues.	Cell pitch.
Asphalt, asphalt pitch	Distillers' waste	Salts of resin acids.
Brown coals	Molasses	Albuminates and tannic acid or tanning liquors.
Petroleum residues.	Carragheen moss.	
Starch paste.	Paper pulp (cellulose)	
Maize meal.	Sulphate cellulose liquor.	

Naphthalene.—This tar product forms in the solid state yellow plates. Recently it has been proposed by Buss to use it as a substitute for pitch, especially in cases where it is desired to briquette moist coal without special drying. So far as is known, the experimental briquettes produced have had only a very low strength.

Asphalt and Asphalt Pitch.—Asphalt is very closely allied, and possesses similar properties to coal-tar pitch, and has also been suggested as a briquetting medium. Generally, however, and particularly in Europe, the material is far too costly and finds much more suitable application, such as in road construction. Only in certain oversea countries where the material is not so scarce, such as for example, California, is asphalt, or better still the pitch which is derived from it, used in coal briquetting.

Brown Coals.—The compression of coal slack with earthy brown coal is dealt with in an appendix to Part II (Briquetting of Brown Coals) under the heading, "Preparation of Mixed Briquettes of Pit and Brown Coals."

Petroleum Residues.—True petroleum or naphtha is not suitable as such for a binding material and furthermore it is too costly. Under certain conditions, however, the residues of petroleum distillation can render good service.

After the fractional distillation of the various light volatile constituents up to 300° C. there remains in the distillation still a viscous, dark green to black mass (called astatki by the Russians, and masut by the Tartars) which is often used in the regions of the Baku oilfields and in North America for firing purposes in steamships, locomotives, and in industrial installations.

A portion of this residue is, however subjected to further distillation and the products, after purification, form mineral lubricating oils of great value. If the process is not carried too far, the residue is maintained in a plastic state, in which condition it finds application in the manufacture of black varnishes, and in some places it is used as a binding material in the briquetting industry.

By mixing Russian anthracite dust with naphtha residues, briquettes which have an evaporative power of 9·7 and burn with an almost complete absence of smoke are obtained.[1]

In various Asiatic places very favourable results have been obtained with Sumatra residues[2] In Western Europe coal briquetting with petroleum residues is principally carried on at St Etienne[3] by a company which also produces petroleum briquettes from petroleum without the addition of coal, by a sort of saponification process. These briquettes should have a calorific value of 9000 cals.

Starch Paste,[4] Wine Lees Residues, and Brewers' Waste.[5]—The great binding power of starch paste led to its use as a substitute for pitch on an experimental scale a very long time ago Recently the preparation of briquettes with starch paste and water or lime and magnesia has been recommended by B. Dumont du Voitel of Memel and also by T. Lee of London Flour, ground oil cakes, potato meal, and all organic farinaceous materials, particularly spoiled flour, can be used for starch Apart from spoiled flour, which is cheap enough but is only obtained on rare occasions and can hardly therefore be taken into account, there are other more or less valuable materials of which better use can be made in other directions, whose use in sufficient quantities would bring about relatively high costs. This applies to the wine lees residues and the residues from distilleries and breweries such as have been used by H. Zippel of Zwickau.

Carragheen Moss or Pearl Moss.[6]—This is a variety of seaweed occurring on the Atlantic coasts, more especially on islands. On boiling with about 25 to 30 times its volume of water it yields a gelatinous mass possessing good binding properties. Although repeatedly introduced into practice, this binding material has not been able to maintain its position, since it cannot be obtained at a sufficiently low price, and further, the briquettes produced with it are not capable of resisting the influences of weathering.

Molasses.[7]—Although, on account of the content of sugar and gummy compounds, an addition of only 1 to 5 per cent. of the molasses obtained in sugar refining is sufficient to act as bond, this material has not proved very satisfactory for the purpose, since briquettes made with molasses can carry no water and must therefore be completely

[1] According to Roux, *Oestr ch T.-Ztg* , Jan. 1, 1902.
[2] Gluckauf, 1897, p. 472.
[3] Gluckauf, 1902, p. 705.
[4] Preissig, p. 86, and Steger, *Z. f. B.-, H.- u. S.-W.*, 1902, pp. 313-314.
[5] Steger, *ibid.*
[6] Preissig, p. 86.
[7] Preissig, p. 87, and Steger, p. 314

dried before they are stored or shipped. The utility of molasses is not materially increased by the addition of linseed oil or burnt chalk.

Paper Pulp (Cellulose).[1]—This material is made from woody fibre and is much too costly for the purposes of briquetting. Experiments made by C. Hilts at the Neu-Laurweg mine at Kohlscheid have shown that the briquettes produced even after the most careful drying are not stable against the influences of moisture.

Sulphite Cellulose Liquors (Cellulose Waste).[2]—The liquors of sulphite cellulose factories, formerly a troublesome waste product whose introduction into the rivers led to many disadvantages, have been the starting-point of various more or less valuable briquetting materials. According to Mitscherlich, a material somewhat similar to gum arabic in adhesive properties can be obtained from sulphite cellulose liquors in the following manner.—

"The liquor is treated with lime until it is very faintly alkaline or with chalk until it is practically neutral. In this way calcium sulphite is caused to separate out. The liquor is then introduced into an osmosis apparatus. The liquid flowing from the apparatus carries with it most of the inorganic materials, fermentable bodies, etc., while the residual material contains the real adhesive substances in combination with lime. This is treated with sodium carbonate until the precipitation of the calcium carbonate is complete."

The dark-coloured sodium compound obtained in this way forms a very good adhesive substance which does not absorb moisture and can be obtained at a very low cost. The briquettes made with it should therefore show very little tendency to crumble.

A still cheaper binding material, prepared by another method of Mitscherlich's[3] and consisting of compounds of the organic substances of the sulphite cellulose liquors with lime, also possesses considerable adhesiveness. However, it produces briquettes which contain a greater proportion of ash and give a correspondingly lower calorific value. The remaining properties are very similar to those of the briquettes made with the sodium compound. The tendency to absorb moisture is only very slight.

C. Fiedler of Munich proposes to make briquettes with the aid of a mixture of unconcentrated sulphite liquors, lime, and blood, which possess adhesive properties in a very high degree. The most suitable mixture is as follows.—

87 per cent.	small coal.	2 per cent.	blood.
10 ,,	sulphite cellulose liquors.	1 ,,	lime.

[1] Preissig, p. 87, and Steger, *Z. f. B.-, H.- u. S.-W.*, 1902, p. 314.

[2] Steger, *ibid.*, p. 531.

[3] Steger, *Z. f. B.-, H.- u. S.-W.*, 1902, p. 315.

The lime prevents the decomposition of the albumen in the blood. Complete drying of the briquettes cannot be dispensed with.

According to E. Pollaczek[1] of Budapesth the liquors should be mixed with a little lime or magnesia before any preliminary concentration. The most satisfactory mixture is said to be—1 part liquor, 5 parts small coal, and 1 per cent of quicklime. Briquettes prepared in this way require to be dried so that the heat saved by omitting the evaporation of the liquors must subsequently be used up.

In Popplewell's[1] method the liquor is evaporated to a thick syrup and then mixed with the crushed fuel. The briquettes so prepared do not resist the action of the weather, and must therefore be used quickly.

E. Trainer[2] of Bochum evaporates the liquor to the consistency of pitch, in fact to dryness, by which means the sulphur compounds are decomposed. In order to complete this without heating to too high a temperature, which would bring about coking of the liquor, tar-product, asphalt, resin, wax, or lime is added during the evaporation.

Cell Pitch.—Cell pitch is obtained from the waste cellulose liquors by evaporation of the water until the substance is dry. It is prepared by the Edward Mining Co of Langen, in the Darmstadt district, and costs about 35 to 40 marks per 1000 kgs., so that it is just about as dear as coal-tar pitch.

Up to the present time cell pitch has not been applied to the briquetting of pit and brown coals with success, since the resulting bricks are not sufficiently weather resisting. By subsequently roasting the briquettes in heated rotatory kilns, the binding material is coked and the blocks become more weather resisting, but this process not only considerably increases the cost of production, but a large amount of waste is formed and the appearance of the briquettes suffers.

In the briquetting of pit coal an addition of about 5 per cent. cell pitch is used. This is about 2 per cent less than the amount of coal-tar pitch which would have to be employed. In addition, the cell pitch possesses the advantage that it produces no smoke during combustion, but since it has practically no heating value, it cannot contribute to the calorific power of the fuel.

In the briquetting of flue dust and ores cell pitch has proved to be of great value. An addition of 4 to 5 per cent is found to confer great strength on the briquettes of these materials.

[1] Steger, *Z f B.-, H.- u S.-W.*, p 315

[2] Specifications to German patent 10*b*, 130,322, and additional patent, 142,862.

Resin Salts and Resin Soaps.[1]—The adhesive power of resin salts has already been proved in other industries, such as paper-making.

F. Linde of Dortmund suggests using them, particularly for the briquetting of small coke

Count Dillon de Micheroux of Namur uses as binding material a mixture of tar and resin which when heated with caustic lime forms resin soaps. Although possessing very high adhesive powers, resin soaps appear to be far too costly to find any general application.

Albuminates. According to F Hulwa of Breslau, the small coal to be briquetted is moistened with liquids containing animal or vegetable albuminoids (albumin, fibroin, and the like), thoroughly mixed with quicklime or magnesia and then moulded Suitable liquids are blood waste, white of eggs, and stale milk The usual proportions are 300 parts by weight of small coal, 20 parts by weight of blood or substance of equal value and 5 to 10 parts by weight of lime On briquetting this mixture very strong and weather-proof briquettes can be obtained without the use of very high compression pressures In a recent improvement of the method the alkaline earth is replaced by tannic acid or liquors containing tanning materials In this a lower content of ash and higher calorific value are conferred on the briquettes.

IV. Inorganic Bonds

The materials used in the clay and building industries are to be regarded as the most important of the inorganic binding materials The amount added must be limited to the very smallest possible quantity, otherwise the ash content of the fuel will be raised to quite an unnecessary degree. Consequently, only bodies with a very high adhesive power which rapidly comes into action can be used with any chance of success.

Clay.—It has already been repeatedly pointed out (p xxi) that the use of moist clay in the hand moulding of spherical lumps has been handed down from the olden times The results do not adapt themselves to transport and storage, and can therefore only be applied in the immediate neighbourhood of production, and only as domestic fuels.

Magnesia or Sorel Cement.[2]—The extraordinarily high binding power of a mixture of magnesium chloride solution (30 B) and ignited magnesia was discovered by Sorel and is now well known. Its use in the briquetting industry was introduced by A Gurlt A satisfactory mixture can be made from 30 parts of a 45 per cent solution of magnesium chloride, 30 parts of 93 per cent magnesia, and 60 parts water The

[1] Steger in *Z. f. B.-, H.- u S-W*, 1902, p 315. [2] A. Gurlt, p 36, and Steger, *ibid*, p 317.

resulting pressed coals prove to be weather resisting, they can be stored and behave well in the fire, but they must be properly dried before transport. At the same time the increase of the ash content is very troublesome, since about one-half of the 5 per cent. of binding material which must be added in order to get good results remains behind as ash. This, coupled with the high price of the cement, has prevented its general use, and the high hopes placed upon it have not been realised.

Ordinary or Portland Cement.—This material is much cheaper, but does not possess such great binding power as magnesian cement. The complete setting and hardening of the briquettes also takes a much longer time.

Calcium Hydrate or Milk of Lime.—For rapid hardening calcium hydrate must have access to carbon-dioxide, in order that it may become converted into calcium carbonate. The waste gases from industrial firing installations form a cheap source of this material. At the Salgo-Tarjaner collieries in Hungary[1] this is effected by producing flat briquettes with milk of lime, and subjecting them to the action of chimney gases in a chamber, when they acquire strength owing to the absorption of CO_2. The briquettes maintain their shape and do not fall to pieces in the fire. Apart from the low value of the blocks, the method is complicated and costly.

Admixture with lime provides the advantage that in pyritic coal the sulphur dioxide evolved on combustion is absorbed. Under certain conditions, lime may reduce the amount of smoke produced.

With moist coals, unslaked lime may be applied as bond, thus obviating the necessity for drying the briquetting material. Plaster of Paris can also be applied with the same object.

Water glass, a material which finds a good deal of application as a cementing medium in the earthenware and mortar industries, is far too dear to be of any use in briquetting.

V. Review.

From the above accounts, and consideration of the various organic and inorganic binding materials, it is obvious that the numerous experiments, which have been continued right up to the present time, have not given completely satisfactory results in providing an efficient substitute for coal-tar pitch. When the output of pitch is sufficiently great and the price moderate, there is no urgent necessity for the provision of another binding material. However, when there is a scarcity

of pitch and the prices rise accordingly other less-prized materials such as resin, asphalt or asphalt pitch (when the cost of these materials is sufficiently low — a set of circumstances which is rare in Europe), may be used as a partial or total substitute for pitch. The same remarks apply also to treated sulphite cellulose liquors, albuminates, or even certain inorganic substances such as magnesian cement, lime, hydraulic gypsum, and so on. Since, however, the quality of the pressed coals produced by these bodies always lags behind that of the pure pitch briquettes, the substitutes are always dropped and the sole use of pitch again resorted to when the market price justify it. In the long-run, the coal briquetting industry can maintain and extend its field of operations only by the production of pressed coals of the highest quality, a fact which has been proved throughout the whole of its earlier development.

Consequently it is of the greatest interest to the briquette industry that as much high class quality coal tar pitch should be produced as possible. This can best be done as a bye production of the coking and gas plants in the possession of the factories themselves. In this manner there is always an ample supply of pitch at their disposal at very moderate costs, and the demands for pitch can be supplied from the local industries.

C. OUTLINE OF COAL BRIQUETTING — GENERAL CONSIDERATIONS

The following is an outline of the methods of coal briquetting:—

The unwashed or washed small coal intended for briquetting are brought directly from the dressing plant (sieve or washery) with which the briquette factory is generally connected. If the factory is situated at some distance the coal is transported by rail or canal and discharged into storage bins from whence it is removed as required. Under certain circumstances the coal is subjected to a further crushing, but this is always omitted if at all possible. Most, especially washed, coals usually require to be dried.

The binding material, invariably medium-hard or hard pitch, is delivered in blocks or lumps. It is first broken up then pulverised, and added to the fine coal in certain definite percentages which have to be carefully pre-determined for each particular case. The addition may be made after the drying operation, but if this operation is essential, the addition is usually made before drying. The coal and pitch are thoroughly mixed together and, if drying is necessary, the mixing is carried out in one or several heated ovens in which the mass

is warmed up and the excess moisture in the coal removed by evaporation. Then follows the kneading of the mixture, during which operation highly superheated steam is introduced in order to confer the necessary plasticity in the mass. Finally, the mass is compressed under a very high pressure (about 200–300 atmospheres) to briquettes, which are usually ready to be loaded on to waggons. Occasionally it is necessary to store them for some time before shipment.

Deviations from this general course become necessary at times, more especially when another binding material is added to the pitch, when the pitch is added in the liquid form, or even when the pitch is totally replaced by another binding material.

Since even with a moderately high price of the binding materials the costs of the necessary additions become heavy, the question of profits of briquetting demand attention to the following general consideration of the arrangement of the briquette factory :—

1. In order to economise in wages and power, the various operations must, as far as possible, be carried out by simple, mechanically operated or automatic contrivances. These appliances must be so designed, dimensioned, and arranged that :

2. Their working can be easily and rapidly adapted to the variations in the nature of the coal and bond or to the changing conditions of the market ;

3. With expert attention and superintendence a thorough co-operation of the various operations is provided, resulting in the production of the desired quantity of pressed coals of uniform quality with the use of the minimum amount of binding material and the total prevention of waste ;

4. The portions of the mechanical appliances subject to wear should be capable of ready renewal ;

5. The whole briquette factory must in all its parts be readily accessible so as to simplify the superintendence. It should also be capable of extension (when this becomes necessary in order to increase the output) in such a manner as not to affect the existing plant. The installation of the necessary presses and accessories may take place in the existing shop, if originally made large enough with this object in view, or in an outhouse built at a low cost. The new plant should combine with the old one to form a complete unit.

In the following sections the individual operations with the necessary mechanical appliances will first be dealt with. Then a number of the various types of coal-briquetting factories will be described, and the mining regulations applicable to such plants will be discussed. A further section deals with the economics of briquetting, and a number of cost sheets are introduced. Coal-briquetting statistics of the principal briquetting countries of the world form the conclusion of the first part.

SECTION III.

THE SUPPLY AND COLLECTION OF COALS AND BINDING MATERIALS FOR BRIQUETTING.

THE raw materials for briquetting (small coals and binding material) are first of all conveyed to storage bunkers from which they are taken according to requirements. Other appliances and methods of handling are required corresponding to their various origins and physical conditions.

A. COAL.

I. General.

Usually the briquette factory is attached to the dressing plant of a coal-pit either to the screening and washing plant (Lower Rhenish Westphalia, kingdom of Saxony, etc.) or to the dry separation plant alone (*e.g.* Upper or Lower Silesia). There are, however, a number of briquette factories outside the colliery companies and situated at some distance from the colliery districts which furnish the coal for briquetting. They are usually near riverine or sea harbours, or occasionally near railway stations especially where large quantities of coal conveyed in ships or railway waggons can be unloaded, loaded or stored temporarily, so that sufficient quantities of coal slack are produced to make briquetting profitable.

In these two groups of briquetting plants the supply of coal is obtained under materially different conditions. At many installations of the first group (the briquette factories belonging to mining companies) outside supplies from other shafts of the same mine, or even from other collieries are provided in addition to the coal conveyed from the neighbouring dressing plant for the ordinary practice or in special cases where external help becomes necessary. The supply of such outside coal is usually effected by rail, and care must therefore be taken that the unloading and conveyance to the storage bins of the briquette factory may proceed regularly and as economically as possible.

In every case one or more storage bins are necessary, regardless of whether the briquette factory belongs to the first or second group. The coal is charged in at the top, and the quantities of coal required for briquetting are drawn from below.

The storage bins must be sufficiently large to prevent small temporary dislocations in the supply of coal, which can easily occur in the ordinary practice, causing corresponding derangements in the briquette factory. In the colliery companies' briquette factories, where a regular coal supply can usually be depended upon, at least 1 to 2 hours' supply of coal should be kept in stock in the bunkers, it is better, as is generally the case, that the coal bunkers should be considerably larger, their capacity being equal to a whole day's supply and even more. The briquette factories of the second group, intended for dealing only with outside coal or for working waste slack, obviously require specially large storage sheds in order to be as independent as possible of uncertainties in supply or recovery of slack.

II. Appliances for Conveying Briquetting Coals.

These will be chosen according to the condition, the origin, and the quantity of the coal and the number, position, size, and especially the height of the storage bunkers.

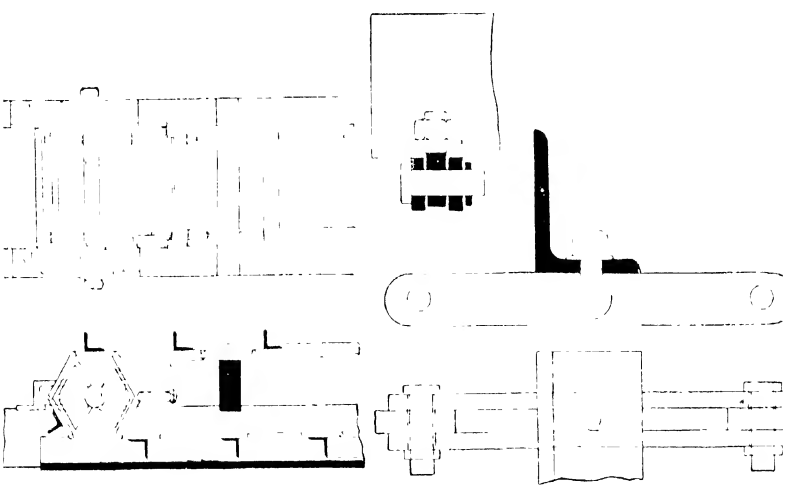


FIG. 10 Scraper band for fine coal.

The removal from the neighbouring screening or washing plants in horizontal or slowly inclined directions is usually effected by endless

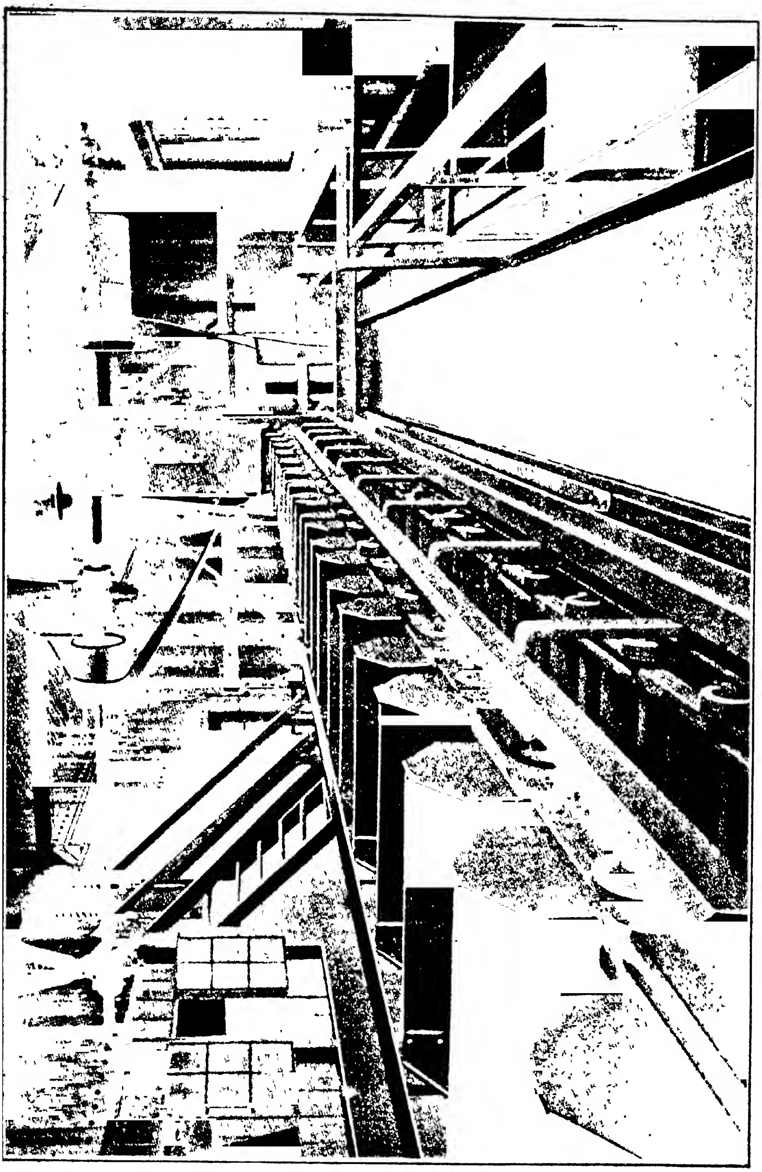


FIG. 11.—Scraper band in the upper space of a coal-storage tower.

band conveyors, which conveniently consist of broad webbing material (especially Balata) or of iron in the form of iron plates attached to two chains connected together and running in the case of dry coal on rollers but for washed and drained coals the so-called "scraper band" is to be preferred.

The scraper band (figs. 10 and 11), also known as the Harken chain, consists of two similar link chains, between which upright iron sheets or angle irons—known as scrapers—are fixed. The chains run on two polygonal centre pieces carrying the belt. One is driven, while the other is provided with a tension arrangement.

As distinct from other belt conveyors the actual conveyance is effected by the lower and not the upper portion of the scraper belt, since the scrapers which hang vertically from the lower halves of the chains push the material (small coal) to be moved along a wooden or iron trough to the point of delivery. Because of the free space between the individual scrapers the scraper belt is able to receive coal to be transported from above such as from the mouths of charging hoppers, etc. at any desired point on its whole length. Fig. 11 shows the scraper band in the large coal storage tower (see also fig. 13) for the ship coals of the Rheinau[1] briquette works built by the Maschinenbau-Akt.-Ges. Tigler in Duisburg-Meiderich for the anthracite coal and coke works of Dusseldorf G.m.b.H. The scrapers of this belt are provided with side plates cut at an angle at the top to keep the moving coal in the trough as close together as possible. At Rheinau the small coal is unloaded from the ship by means of a jib crane with self-acting grabs and discharged into a hopper (see fig. 13 right) from which it is conveyed by the motion of a travelling covered scraper band to the loading pit of a tower hoist. The latter lifts the coal into the storage tower already mentioned and allows it to fall on the upper scraper band (fig. 11) which uniformly divides it between the three divisions of the storage tower.

The so-called conveyors are also suitable for this purpose. They consist of a kind of horizontal elevator with sheet metal troughs pivoted freely to chains running on rollers and can be caused slowly to ascend or descend at any desired angle up to the vertical by means of revolving centre pieces. The emptying of the buckets is completed automatically by means of special tipping arrangements provided at the proper places.

[1] "The Rheinau Coal Briquette Works," Prospectus of the Maschinenbau-Akt.-Ges. Tigler, Duisburg-Meiderich.

At many briquette factories attached to coal-washing plants the filling of the storage bunkers is effected by draining band conveyors (Maschinenfabrik Baum-Herne or Humboldt, Kalk [1]), applied specially of late to coking coals. They are provided with large troughs made of

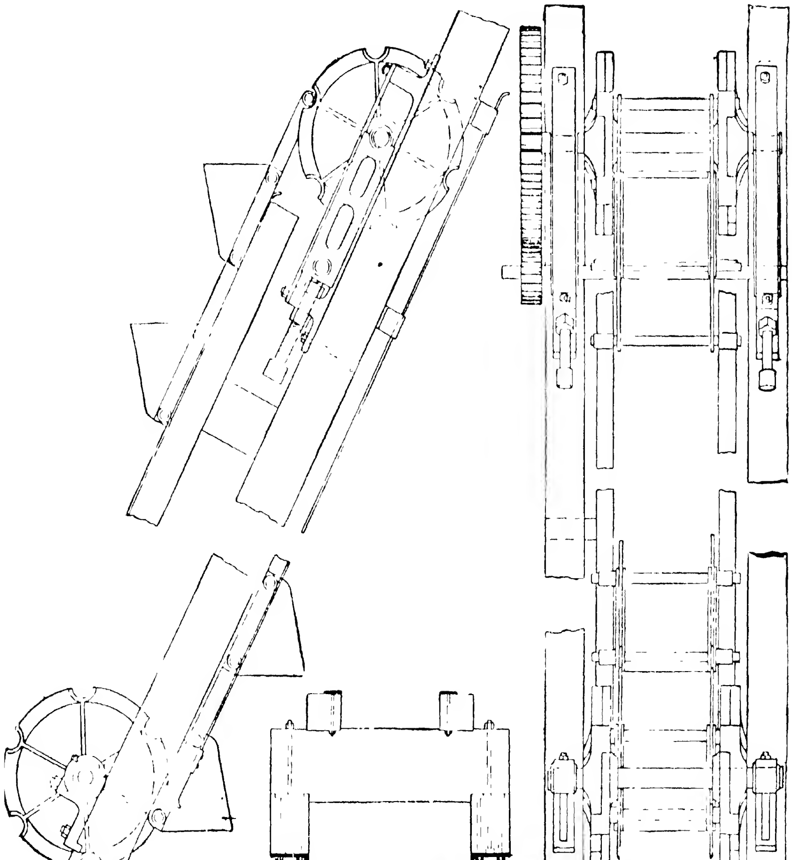


Fig. 12 Elevators.

finely perforated sheet metal, through which the water can trickle away These bands, which also run on rollers, are driven very slowly, both horizontally and inclined

During the horizontal or slightly inclined conveyance of washed

[1] *Niederrhein-Westfal Sammelwerk*, vol ix, 1905, p. 183, fig. 78. Further, Prospectus of the Maschinenbau Humboldt, Kalk, near Koln.

small coal to the storage bins of a briquette factory by means of one of the band conveyors previously described, a simultaneous supply of the unwashed dry-sieved coal dust can conveniently be secured simply by allowing the dust to fall on to the moist fine coal from the conveying chute or band conveyor. This appliance is becoming more and more used. The delivery bands, etc., convey the coals either directly into their destined bins without external assistance or by the aid of an inclined metal chute. Otherwise the coal is fed on to another band conveyor arranged at right angles to the first, or into the masonry pit of an elevator, which undertakes the further removal.

Elevators (fig. 12) are steeply inclined or quite vertically moving endless link chains or ordinary chains, to which buckets are fastened at equal distances for vertical hoisting. These are filled out of a pit or charging hopper and discharge their contents at the top. In preparation plants and briquette factories they are put to innumerable uses; in the latter they are used for the hoisting of coals and fine pitch, either separate or as a coal-pitch mixture. When used for hoisting of wet coals they can serve as draining elevators (made by Schuchtermann & Kremer, Dortmund), if provided with an ample number of finely perforated buckets.

In order to prevent the rapid wear and tear of the link chain, a slow and uniform motion must be imparted to the hoist, especially to drainage hoists, to obtain a more complete removal of the water; further, the size of the buckets must be ample for large deliveries at slow speeds.

Uniform loading and delivery is very desirable and not difficult to effect by placing an automatic regulating slide in the charging hopper, etc. The power necessary for steeply inclined link chain elevators is comparatively high. The drive is effected by means of pulleys and gear wheels with a transmission ratio of 4 or 5 : 1 at most.[1]

III. Coal-storage Bins.

At the smallest installations this purpose is effected by sheet-iron hoppers, the sides of which are inclined at an angle of at least 45° to facilitate free sliding of the coal without tendency to stick. Such hoppers are to be seen below in Section IX. among the illustrations of complete coal-briquetting factories.

For larger stores of coal lasting over a longer period, square, or, better still, cylindrical bunkers of masonry, iron girders or sheet iron and (although very seldom) of wood are used, provided underneath

[1] *Niederrhein.-Westfal. Sammelwerke*, vol. ix., 1905, p. 222.

with metal hoppers, the openings of which are usually circular, and like the smaller bins, can be closed or opened to any desired extent by means of slides. The briquette factory of the Zeche Holland III IV, for example has three such storage bins made completely of iron, holding about 30 tons, and standing side by side in a tower-shaped building for the maintenance of four Tigler presses with a total output of some 50 tons per hour. The new briquette installation of the Zeche Hagenbeck, described in Section IX, also possesses three bins whose main portions are however, built cylindrically (fig. 22).

The previously mentioned coal storage tower of the Rheinau briquette works (figs. 11 and 13), built in three sections and supplied by means of ships is much larger still. It is built for the most part of wood, and consists of three divisions, each of about 200 tons capacity. The conveyance and division of the coal by means of a scraper band in the upper space has already been described (p. 53).

B. PITCH.

The conveyance of hard pitch or medium hard pitch is usually effected by rail since most of it must be procured away from the works. It does not often happen that briquette factories are to be found in the immediate neighbourhood of distillation or coking plants recovering pitch. In this case the transport of the pitch is naturally a very simple matter. The hard and medium hard pitch from tar distillation at coking or gas plants is mostly obtained in cylindrical or conical blocks of the shape of the moulds into which the recovered pitch is poured in the molten state and allowed to solidify, or delivered in pieces of such blocks, the Scottish blast-furnace pitch is, however, supplied in the form of pieces and fragments as they are obtained from the gas mains of the blast furnaces.

At briquetting plants where the pitch supply is carried by rail care must be taken that the pitch is removed from the waggons into the store almost immediately without any special intermediate conveyance. Further, it is of importance that very soft pitches should be kept as cool as possible during warm weather. The pitch store, or at least a portion of it, is therefore often placed below the briquette-loading platform on the ground floor, or in the cellar. This is the case, for example, in the large briquetting plant built for the Zeche Hagenbeck by Schuchtermann & Kremer of Dortmund, and illustrated in Section IX. The greater portion of the pitch store is situated under the long

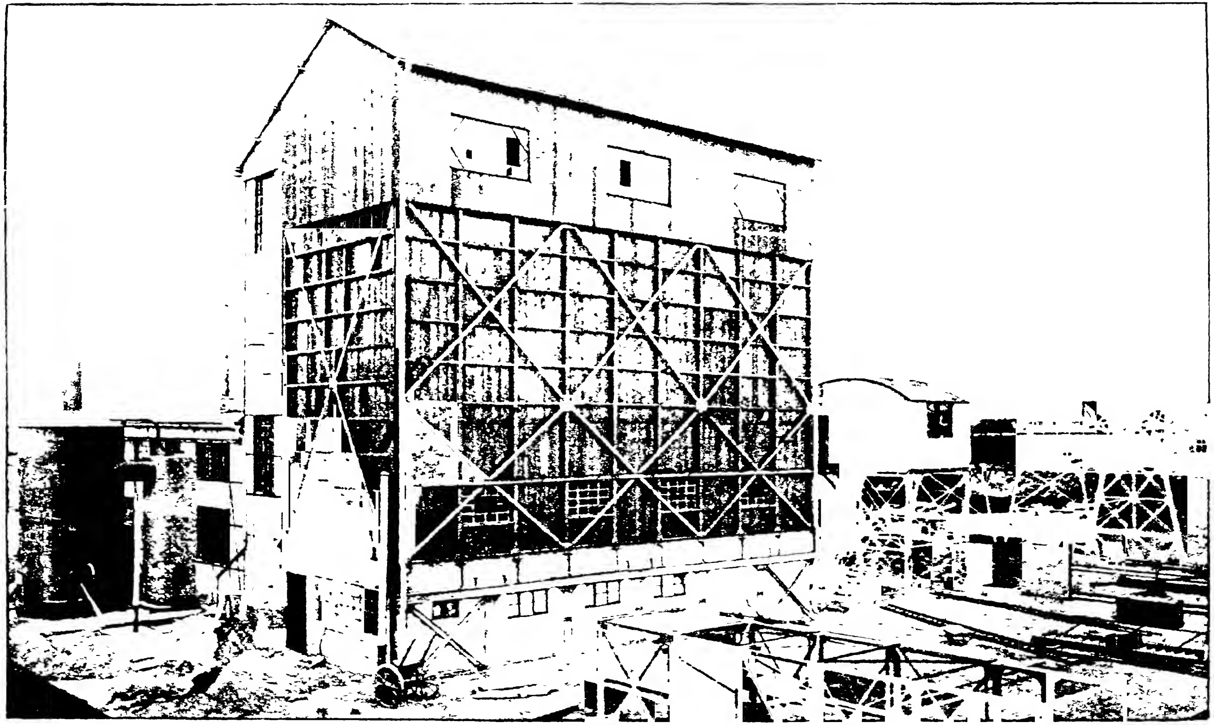


Fig. 13.—Triple-compartment coal storage tower of the Rheinau briquette works. Unloading of coal from the ships by means of a crane at the right. Grab [illegible]

loading stage, and almost stretches along the whole narrow side of the factory building, so that ample stores can be accommodated.

On the other hand, in the briquette factory of the Freiherrlich von Burgker Steinkohlenwerke at Dresden-Planen (see Section IX.), the pitch warehouse is situated close to and behind the supply stores on the first floor, but is, however, on the narrow side of the building and accessible to the railway track.

Inside the pitch store the pitch is usually dealt with by means of hand-barrows, which are also used for carrying the pitch to the preliminary crushing machinery (stone- or pitch-breakers, etc.)

The proper supply and accumulation of large quantities of pitch from external sources is obviously as important as the maintenance of the briquette factory with large stores of coal, for the uniform working of the briquetting plant.

In the comparatively rare case of the liquid soft pitch[1] from a neighbouring coking plant, recovering bye-products, being used as a binding material, the corresponding arrangements of the Zeche Holland III./IV.[2] can be taken as an example. The liquid soft pitch obtained in the firm's own coking plants, after distilling off about half the heavy oil, is allowed to run off through a withdrawal cock into a pressure tank and forced through a pipe 150 mm diameter and 180 m. long directly to the briquette factory by means of pressure steam. The pitch first flows into a large containing vessel capable of holding about 20,000 kg. It is situated over the flat grate of the drying drum and becomes heated sufficiently to always keep the pitch contained in it quite fluid. The chimney of the furnace is also led through the tar-holder for the same object.

The appliances for removing the liquid pitch in a suitable condition and the required quantity are dealt with in the section on Supply, Mixing, and Division.

C. RESIN AND OTHER SOLID BINDING MATERIALS.

The conveyance and storage of the resin[3] required, which is delivered in barrels, as well as other solid binding materials, can usually be effected in the manner previously described for hard pitch.

[1] See above, p. 37.
[2] *Niederrhein.-Westfal. Sammelwerke*, vol. IX., 1905, p. 612.
[3] See above, p. 11.

SECTION IV.

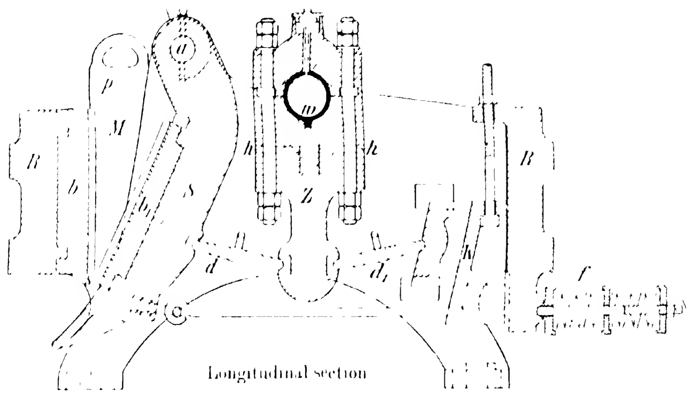
CRUSHING.

I. GENERAL.

THE fine coals of less than about 11–10 mm from the sieving or washing need no further working in special crushing machinery if they are fairly soft such as, for example, nearly all the Westphalian hard, smithy, or semi-fat and fat coals The larger pieces (from 11 down to 3 mm.) are sufficiently broken up in the various supply, delivery, heating, drying, and mixing appliances through which they have to pass on their way to the press, and to some extent in the press itself. With harder coals, *e.g.* Upper Silesian and Saxon, this does not, however, take place sufficiently, consequently, a fine crushing machine (disintegrators and the like) cannot be dispensed with.

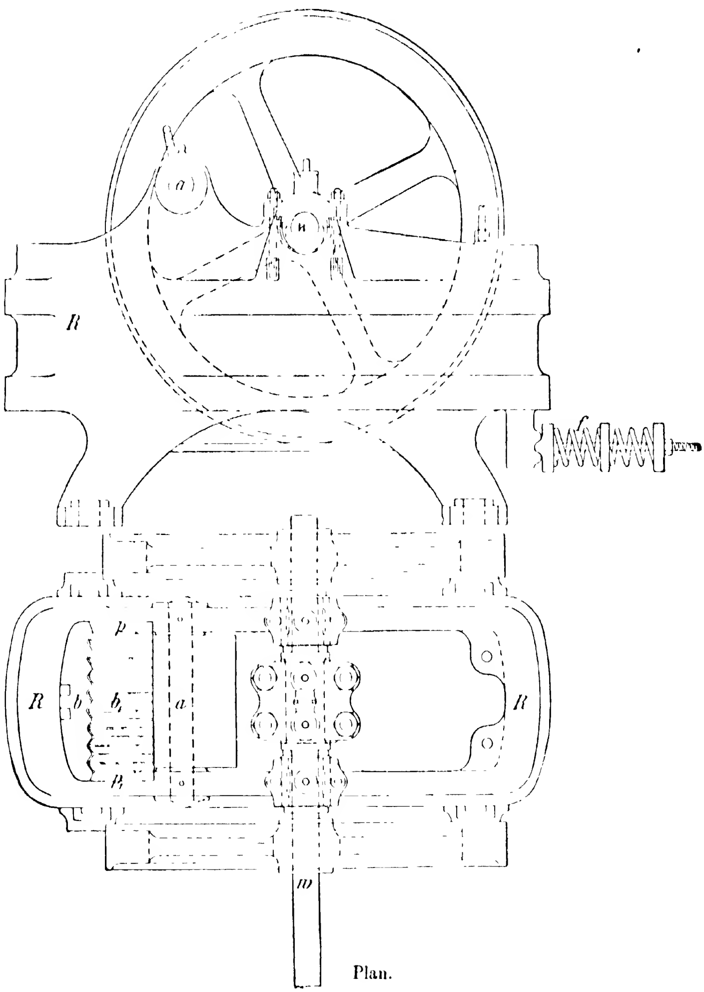
Such machines are necessary in every case for pitch, which is delivered in cylindrical blocks, lumps, and smaller pieces. The blocks are first broken by hand into large pieces by means of a hammer with a long handle, these pieces and the lumps of pitch as delivered are sent on to a preliminary crusher (stone-breaker or crusher, pitch-cracking machine or breaker), and the resulting nuts completely crushed to fine material by means of pitch mills (disintegrators, roll mills). The object is the preparation of grains as uniformly fine as possible, something like coarse sand, without making any dust; but the production of the latter cannot be altogether avoided.

During the supply and crushing of the pitch careful consideration should be given to the proper separation of deleterious foreign materials such as pieces of iron. Experience shows that in railway sidings and even at the pit stations there are to be found old tyre clout-nails, lashing screws, damaged or loosened iron parts of railway waggons, which the railway workers have a predilection for throwing on to goods waggons The waggons in which the pitch is carried can also be affected in this manner. If such pieces of iron are not observed in the



Longitudinal section

Side view.



Plan.

pitch stores and thrown out, they accompany the pitch supply into the crushing machinery, easily causing breakages and other damage, and consequently interrupting the whole working of the briquette factory. This applies especially to the introduction of pieces of iron into the specially sensitive and very rapidly running disintegrators, which should consequently be suitably protected under all conditions in a manner to be described more fully later.

Should, under certain circumstances, a portion of the pitch be replaced by resin, which is usually delivered in the form of small pieces, a ball mill must be provided for crushing. Experiments to apply the existing disintegrators or roll mills to the crushing of resin have proved fruitless (further information below).

In the following pages the various breaking machines are illustrated and described more fully.

II. PRELIMINARY BREAKING MACHINES.

Stone-Breakers (Crushers) (Fig. 14).—The preliminary crushing machines generally applied to the preparation of ores and mineral salts are quite suitable, when equipped accordingly, for the breaking up of large pieces of brittle pitch.

The usual design of stone-breaker used in briquette factories is illustrated in fig. 14. The lumps of pitch are thrown into the wedge-shaped breaking mouth M. This is formed by the vertical breaking jaw *b* fixed in the principal wall of a cast-iron frame R, the inclined jaw b_1 fastened to the pivoted lever S, the side walls of the frame and the two wedge-shaped side plates *p* and p_1. The breaking jaws are made of hard cast iron and are provided with sharp ribs or grooves. They can be changed and reversed, thus considerably increasing the length of service, since the wear at the lower end of the jaws *s* is considerably greater than at the top. The side plates *p* and p_1, fixed in grooves serve to strengthen the breaking jaw *b* and as far as possible to protect the side walls of the frame from wearing; they are made of hard cast iron or cast steel and are easily renewable.

The breaking mouth is alternately narrowed and widened by the motion of the swinging arm S oscillating about the horizontal axle *a*, whereby the pieces of pitch charged are subjected to the crushing action of the ribs on the jaws at both sides, become more and more crushed and broken, and as they become smaller sink lower in the mouth, until finally they fall out of the opening *s* at the bottom.

The motion of the swinging jaw S is obtained from the eccentric shaft w driven by the pulley r, by means of the powerful crank Z and two pressure plates d and d_1 fitting in the head at the bottom. These form a toggle joint in which one of the bars d_1 rests against the back of the body of the machine at the right, while the other d, rests against the lower part of the swinging jaw S. As a result of this arrangement the pressure plates exercise a side thrust when the crank rises, the swinging jaw is forced to the left, and returns when Z falls owing to the action of gravity on the jaw and the tension of the spring f. The irregularities of the running of a stone-breaker are compensated by two heavy fly wheels attached to the driving axle.

The width of the opening of the breaking mouth can be changed by removal of or driving in the wedge K, the stroke of the swinging breaking jaw can be varied by enlarging or diminishing the wooden packing layer h according to the various requirements. For pitch the width is generally about 60 mm.

Stone breakers are made in more than six different sizes by the various manufacturers of dressing machinery.

The firm of Schuchtermann & Kremer of Dortmund deliver the following models of stone breakers:—

No. of Model	Breaking Mouth		No. of revs. per min.	Power used	Delivery per hour	Space required		Weight of the Machine
	Breadth	Length				Length	Breadth	
	mm.	mm.		h.p.	c.m.	mm.	mm.	kg.
I	150	75	210	0·5–0·[illegible]	0·3–0·[illegible]	[illegible]50	500	250
II	200	100	2[illegible]0	[illegible]·5–1·[illegible]	0·7–1·[illegible]	1300	[illegible]0	1100
III	250	125	220	3·[illegible]–2·5	1·0–[illegible]·5	1400	940	1835
IV	300	150	210	1·5–3·0	1·[illegible]–3·0	1600	10[illegible]0	[illegible]100
V	400	200	210	[illegible]·0–5·0	3·0–6·0	1850	13[illegible]0	4180
VI	500	300	200	1[illegible]·5–8·0	6·0–12·0	2150	1650	6680

For running a briquette factory with two presses having a combined output of 10 tons of briquettes per hour, using a medium quantity of pitch of 7 parts per cent.,

$$\frac{10 \times 7}{100} = 0{\cdot}7 \text{ ton pitch per hour};$$

for a four press installation,

$$\frac{20 \times 7}{100} = 1{\cdot}4 \text{ tons pitch per hour},$$

for a six-press installation,

$$\frac{30 \times 7}{100} = 2{\cdot}1 \text{ tons pitch per hour}$$

must be crushed by the stone-breaker if the whole of the pitch has to pass through it.

Zeitz Pitch-Crackers[1] (figs. 15 and 16). The Zeitzer Eisengiesserei- und Maschinenbau-Aktiengesellschaft have installed the so-called pitch-crackers for the coarse or preliminary crushing at several of the coal-briquetting factories which they have built. Figs. 15 and 16 show a cracker with a discharge and mixing spiral arranged underneath, such as was made, for example, for the working of the plant laid

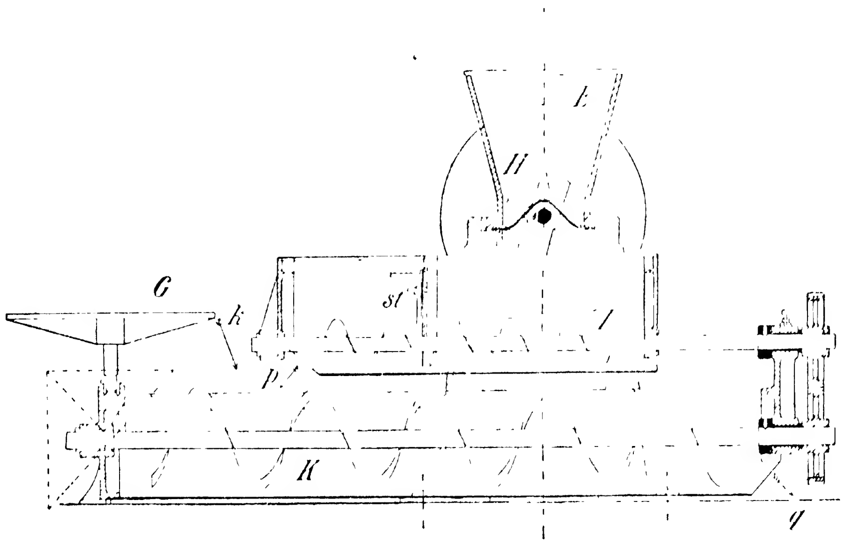


FIG. 15.—Pitch-cracker with discharge and mixing screw: longitudinal section.

down by the Steinkohlenwerks Bockwa-Hohendorf Vereinigt Feld at Lichtenstein in Saxony in 1902. The cracker consists of a number (six at the most) of solid steel grate bars bent upwards between which are placed, so as to leave very little play, rhombic shaped breaking plates capable of revolution. These are keyed next to each other on a shaft situated under the bend of the grate; their distances apart are determined by rings pushed on the shaft and held in position by means of the nuts *s*.

The pitch is charged by hand in pieces about as big as the fist, into the hopper E, and falls, after sufficient crushing by the rapidly revolving breaking plates, into the worm conveyor I. The rate of delivery

[1] E. Treptow, "Das Brikettieren der Steinkohle im Königreich Sachsen," *Jahrbuch für das Berg- und Hüttenwesen im Königreich Sachsen*, 1907, p. 14A.

can be regulated by a slide *st*. At *p* the small pitch falls into the mixing worm K, where it is combined with the predetermined amount of small coal which falls from the revolving table G at *k* and the two are carried towards the other end of the worm, becoming thoroughly mixed together on the way. At *q* the whole is carried away to a Carr's disintegrator to complete the crushing.

Compared with the stone-breaker, the cracker is distinguished by a considerably finer and more uniform preliminary crushing of the pitch—of course the pitch cannot be dealt with in such large pieces—but principally, however, in that it is more certain to retain on its grate the foreign materials present in the pitch, such as pieces of iron and wood, thus protecting the disintegrators, which are mostly used for the final crushing.

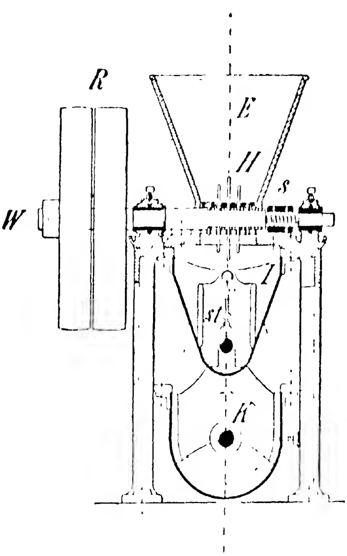


FIG. 16.—Cracker, cross-section.

Pitch-breakers of the Holzhauserschen Maschinenfabrik[1]—The pitch-breaker (legally protected) built by the Holzhauserschen Maschinenfabrik G. m. b. H. at Augsburg, and used with excellent results during the last few years in Lower Rhenish Westphalia (among others by the Zeche Margarete at Solde and by the Zechen Katharina at Kray, and Karl Funke at Kupferdreh in Hessia, belonging to the Essener Steinkohlenbergwerke Aktiengesellschaft in Essen), is similar to the previously described crackers. The breaker shaft is provided with a large number of rhombic steel knives, and travels at the rate of 200 revolutions per minute. Grate bars are not provided, as in the pitch-crackers. On the contrary, the pitch thrown into the hopper is thrown against an opposing system of knives in the direction of rotation of the shaft and cut up in a shearing fashion. If, during the use of soft pitch, some of the material adheres to the knives on the breaker shaft, it is scraped off again by the arms projecting from the other side. The spaces between the knives are from 10 to 20 mm. wide depending on the size of the machine. All the knives are individually, easily,

[1] "New Pitch-breakers," *Der Bergbau*, 1908, No. 12, pp. 8–9.

and conveniently replaced. The wear and tear, however, is only very small. If a large or small piece of iron accidentally falls into the machine, experience has shown that the chances of its passing through are as good as excluded in consequence of the high speed of the machine. It is more likely to be held fast by the reciprocal knife systems, bringing the friction clutch into action immediately and preventing damage to the breaker. The noise made by the friction coupling immediately attracts the attention of the attendant to the stoppage, and he is able, after pushing the belt on to the loose pulley by means of the belt fork, to clean the machine so conveniently and rapidly that a real interruption of the work can scarcely occur.

As further advantages of the pitch breaker, the lower power required, which, compared with an ordinary jaw crusher or roll mill giving the same output, is more favourable to the extent of 40 to 50 per cent., and the lower first cost, which is over 50 per cent. less than that of a jaw crusher, are urged.

III. FINE PULVERISING MACHINERY.

Centrifugal Machines (Disintegrators), figs. 17 and 18. The final pulverising of pitch down to pieces below 60 mm. is mostly effected by a centrifugal mill usually built on the principle of a Carr's disintegrator. Figs. 17 and 18 show longitudinal and cross sections of such a machine made by the Zeitzer Eisengiesserei und Maschinenbau Anstalt.

The centrifugal mill consists essentially of a system of horizontal steel bars arranged round the driving shaft $w\ w_1$ in the two concentric drums $t_1\ t_3$ and $t_2\ t_4$, and combined to two baskets by means of the vertical, wrought iron discs $s\ s_1$ and the cast iron shoulder pieces $K\ K_1$. These baskets are keyed on to driving shafts lying in the same straight line, and are pushed into each other in such a way that the drum of one basket can revolve in the annular space of the other.

The drive of the centrifugal mill is obtained by two pulleys $r\ r_1$ fastened to the shafts, which can make the baskets revolve exceedingly rapidly in opposite directions. This is effected from one and the same transmission shaft in a very simple manner, one pulley being driven by an open, while the other is driven by a crossed belt. The baskets are enclosed by an easily removable sheet-metal cover g, one side of which is provided with a funnel-shaped charging arrangement F.

The material to be ground, brought into this funnel, falls first into the inner drum whose rapid rate of revolution imparts to it a high velocity, and in consequence of centrifugal force it strikes violently

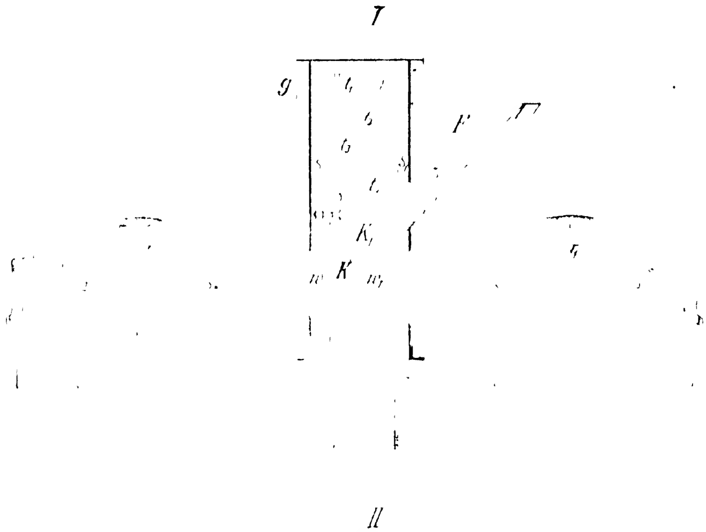


FIG. 17.—Centrifugal mill, longitudinal section. Scale 1 : 30.

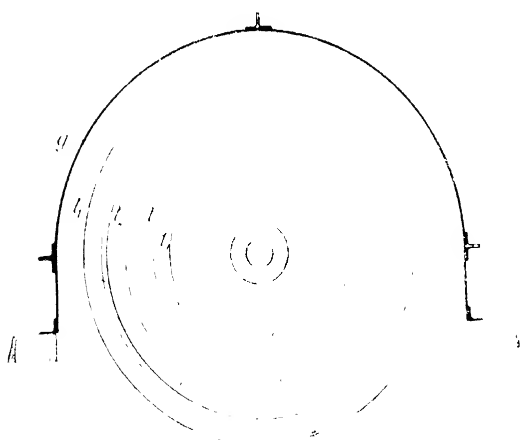


FIG. 18.—Centrifugal mill, cross section. Scale 1 : 30.

against the bars in the second drum which is moving in the opposite direction, and in this way the material gets broken up. A similar, but more violent, pulverising is caused by the bars in the third and fourth drums, until finally the ground material is thrown out of the fourth

drum and caught by the sheet-metal cover, which is provided with an opening underneath through which the material is carried away in a hopper

In order that the badly worn steel bars may easily be replaced, one of the baskets is arranged so that it can be removed. This is brought about in many centrifugal mills simply by turning a hand-wheel provided with a screw spindle. Since the material delivered has, during the operation, been thrown backwards and forwards from one drum to the other, an intimate mixture is obtained in addition to the pulverising which is of advantage in view of the irregular nature of the material to be ground, and qualifies the centrifugal mill for the simultaneous grinding and mixture of various materials, such as coal and pitch, supplied to it. Above all, the apparatus delivers a very loose product, and is well adapted for dealing with moist materials, such as for example, washed coals and very wet brown coals for the purposes of coking and briquetting On the other hand, it is not suitable for more than medium hard materials on account of the great wear and tear on the steel rods, nor for resin, since this becomes soft and sticky because of the heating owing to the great amount of friction in the centrifugal mill Soft pitch behaves similarly and does not generally submit to pulverising, while the hard pitches can be beaten down to the finest grain very completely in the centrifugal mill.

A disadvantage of the disintegrator is that, in consequence of the high rotatory velocity, it can easily be subjected to considerable damage by the introduction of pieces of iron or other hard bodies.

The costs of renewal of the disintegrator occasioned by the accidental charging of even a $\frac{5}{8}$–$\frac{3}{4}$-inch screw or nut can attain the sum of 50 to 60 marks.[1] But the damage is much greater when, in consequence of a breakdown of the disintegrator, the running of the briquette factory must be stopped for hours. In order to prevent such derangements, absolute care should be taken that such foreign bodies are completely separated and removed before the pitch is supplied to the centrifugal mill. The simplest method of doing this is by the application of a pitch-cracker or breaker, as previously described, or of some similar design for the preliminary breaking.

The method already applied for a long time at most of the stone and potash salt grinding materials with good results, for previously separating pieces of iron which would be dangerous to the rapidly revolving fine mills, is somewhat more involved The material delivered

[1] *Der Bergbau*, 1908, No. 12, pp 8–9.

for grinding is first passed through a shaking sieve and then allowed to pass powerful magnets in the form of horse-shoe, steel, or electro magnets placed at the entrance to the fine mill (beater mill, etc.)[1]. Those pieces of iron which have not already been separated and removed by the shaking sieve are attracted by the magnets on both sides of the entrance to the fine mill and usually held there until they are removed by hand. Nothing stands in the way of the use of such magnets in briquette factories during the pulverising of dry pitch.

The following table, taken from a prospectus of the Maschinenbauanstalt Humboldt, Kalk, near Koln, contains further accounts of the most important measurements, power requirements, number of revolutions, output, etc., which have been fixed by experiments on coals for the manufacture of coke as well as for other fine meals.

TABLE OF CENTRIFUGAL MILLS: MASCHINENBAUANSTALT HUMBOLDT.

Model Number	1.	2	3	4	5	6	7
Diameter of the outer drum, mm	500	640	800	1000	1250	1600	2000
Inside diameter of the outer drum, mm	125	160	200	250	320	400	500
Pulley: Diameter, mm	200	260	320	400	500	640	800
Pulley: Width, ,,	100	120	150	190	230	280	330
Power used in H.P.	2-3	3-5	5-8	8-12	14-20	24-32	36-45
Number of revolutions per minute for crushing coal	720	540	450	350	280	220	180
Approximate output of coal per hour, kg	2000	3500	6000	11,000	20,000	32,000	48,000
Number of revolutions per minute for preparation of fine meal	1000	900	800	600	450	300	220
Approximate hourly output of fine meal, cm	0.5-0.7	1.25	2	4	9	15	25
Space required for erection: length, m	1.4	1.7	2	2.4	3	3.7	4.3
Space required for erection: width, ,,	0.9	1.1	1.2	1.4	1.7	2	2.5
Space required for erection: height, ,,	0.6	0.8	1.2	1.5	1.8	2.2	2.6
Approximate weight of the complete machine: four drums, kg	600	1000	1900	2500	4300	7200	11,500
Approximate weight of the complete machine: six drums, ,,		1060	2050	2700	4700	7800	12,400

The correct number of revolutions of the centrifugal mill always depends on the kind of material to be crushed and the fineness of the final product. In contradistinction to other crushing machines, the output is diminished by increasing the speed, but the material ground is finer. The reverse takes place on diminishing the rate of revolution.

Pitch is pulverised by the centrifugal mill to a very fine grain (coarse sand) of the highest possible uniformity, but not to fine meal

[1] L. Loewe. *Die bergmännische Gewinnung der Kalisalze Deutschland's Kalibergbau*, Berlin, 1907, pp. 136-137.

or dust size. In spite of this, the formation of a certain amount of dust cannot be avoided. Consequently the sheet metal cover surrounding the mill must be made dust tight, the bearings of the shaft must be protected against dust and provided with dust proof lubrication appliances, preferably with ring lubrication. With regard to the quantity of pitch to be pulverised, what has been said with regard to stone-breakers (pp. 60, 61) applies equally well here.

For a two press installation, for example (Couffinhal system), yielding ten tons of briquettes per hour for which 700 kg. pitch are necessary, the smallest centrifugal mill, model No. 1 (power required 2 to 3 H.P.), will consequently not only answer the purpose well for pitch alone, but will still have sufficient in reserve for an extension of the plant to four or five presses.

If the whole of the coal to be briquetted is to be pulverised at the same time, a state of affairs which may become necessary when dealing with coal of a hard nature, it must be determined whether the coal shall be treated (1) alone in a special mill, or (2), together with the pitch in a combined disintegrator. In practice both processes are to be found. The combined crushing in one mill offers the advantage over separate crushing in two mills of a simultaneous intimate mixture of the two materials as well as economy in cost of installation and space, but has the disadvantage of less certainty in operation, since the whole working of the briquette factory depends upon one continuously running overloaded mill. Separate crushing offers greater certainty in this respect, and also allows better adaptation to the changing nature of the coal or pitch by correspondingly altering the rotatory velocity of one or the other of the mills, or by putting the coal disintegrator out of action in cases where the briquette factory is supplied with a softer coal.

If all the coal is centrifugalised for a two press or 10-ton briquette factory, a disintegrator capable of giving at least 9300 kg. per hour is required, such as model No. 4, which, for an output of 11,000 kg., requires 8 to 12 H.P. If coal and pitch are treated together in one mill, 10,000 kg. per hour will be required for a plant of equal size, and the same model, No. 4, would be adaptable.

For the provision of three to four Couffinhal presses, model No. 5, with a power requirement of 14 to 20 H.P., would be applied.

Where a soft coal has to be pressed almost exclusively, such as in Lower Rhenish Westphalia, the work is now carried on without a coal disintegrator, thus effecting considerable saving in running power.

Roll Mills (figs. 19 and 20).[1]—At a number of briquette works in Lower Rhenish Westphalia, roll mills, such as are often used at the local collieries for pulverising pit shale for brick-making, are applied instead of centrifugal mills.

The usual design of these roll mills is represented in section and perspective by figs. 19 and 20. The bevel gear-wheel *a*, driven by the transmission pulley, sets the grinding table *b*, consisting of hard cast-iron plates, in motion about its vertical axis. The sieve ring *c*, provided with cast-iron or steel sieves, is screwed on to the grinding

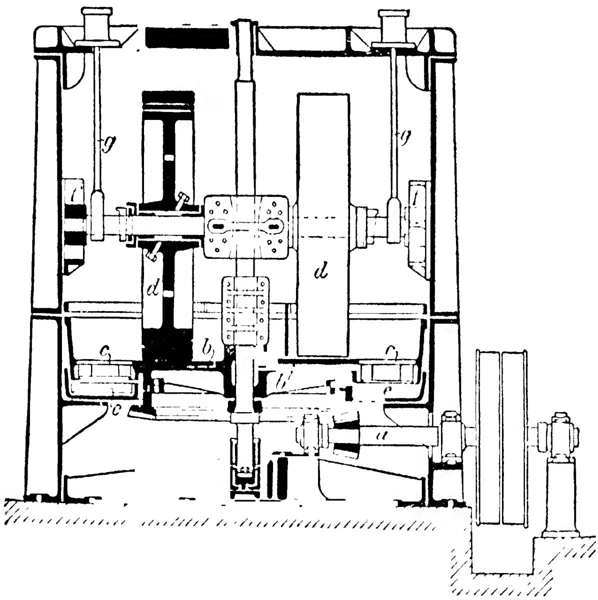


FIG. 19.—Roll mill with rotating grinding track and renewal sieve plates. Section.

table, on which stands two heavy runners *d* of 4000 to 5000 kg weight, with cast-steel or hard cast-iron rings keyed on to the circumferences. When the table moves, friction is set up between it and the runners, causing them to revolve in a vertical plane about their horizontal axis, and partly crushing, partly grinding the material supplied. The rolls can rise and fall in the solid guides of the framework. In order to minimise shock consequent upon the charging of material which is too hard or too thick, the common runner axle is supported by the two bars *g* pressing against two powerful spiral springs in the cross-head.

The pitch broken by means of a stone-breaker or the like is usually

[1] *Niederrhein.-Westfal. Sammelwerke*, 1905, vol. IX. p. 680.

allowed to fall directly on to the grinding table *b*, and, by means of two scrapers arranged above the table, is automatically and alternately led under the runners and on to the sieve ring *c*. The sufficiently crushed material passing through the perforations of the sieve plate falls on to the annular collecting table almost immediately below, while the larger pieces are again automatically passed under the runners.

The sieved small pitch is scraped continuously from the collecting table by several workers into one place, either the feeding hopper of an elevator, or in a chute, slide, or worm

The renewal of the runner rings, grinding and sieve plates must be

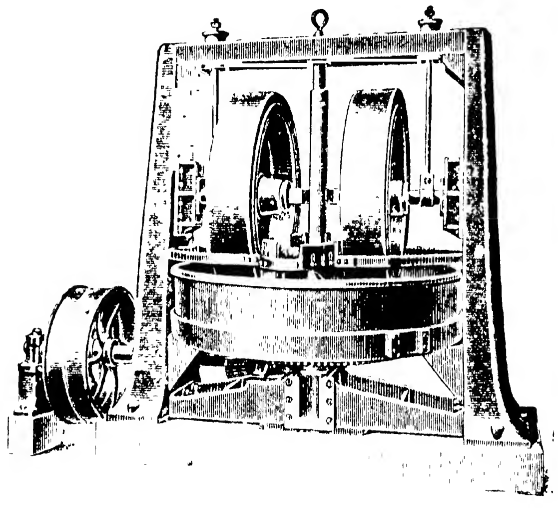


FIG. 20.—Edge runner of the Dorstener Maschinenfabrik.

effected every six to twelve months, according to the hardness of the material dealt with.

Edge-runners are made by the makers of the preparation machines in about seven different sizes. The table on p. 70 gives a review of the measurements, output, power required, etc., of the edge-runner mills with renewable hard cast-iron runner rings and base plates built by the firm of Schuchtermann & Kremer.

In consequence of the inevitable formation of dust during the dry grinding of pitch, the edge-runner must be covered with a closed dust-tight sheet-metal cover built in several sections.

The edge-runner is well adapted for grinding quite solid hard and brittle pitch, but less suitable for medium pitch, which on hot summer

days becomes squashed out and smeared about under the heavy load of the runners Compared with centrifugal mills, edge-runners have the advantage of a slower and more even running, lower wear and tear, and lower consumption of power.

Model No.	Runners Diameter	Runners Width	Weight of Runners.	Power required	Output per hour	Driving Pulley Diameter	Driving Pulley Width.	Revolutions per minute	Space required. Length	Space required. Breadth	Weight of Machine
	mm	mm	kg	H P	kg	mm.	mm		mm	mm.	kg
I	400	125	120	0.5	60	400	75	80	1100	750	600
II	500	150	180	1	120	470	90	66	1500	960	1,100
III	750	200	450	2	250	715	120	56	2000	1280	2,200
IV	1000	250	925	3	500	920	160	40	2900	1600	4,400
V	1250	300	1700	5	1000	1250	160	38	2900	1950	7,200
VI	1500	350	3200	8	1,550	1550	180	28	3100	2250	14,500
VII	2000	400	5000	12	2,500	2010	200	25	3900	2600	20,000

Other Fine Mills. In addition to the machines already described, several other well known fine mills, *e.g.* "beaters" (dismembrators), can be well adapted for grinding pitch These, which, like the centrifugal mills, depend upon the principle of centrifugal force, find considerable application in the grinding of potash salts Further, the Gloria mill used at Stassfurt for the same purpose with excellent results, and which has, among others, the advantage of not being particularly sensitive to pieces of iron introduced, and perhaps the cross-beater mill (disaggregator), could also find some application But there seems to have been no experiments made in this direction.

For finely pulverising resin, which was a few years ago temporarily applied as a partial substitute for pitch in Lower Rhenish Westphalia in consequence of a scarcity and extraordinary high prices of pitch, centrifugal mills were only little used on account of the reasons given above, while ball mills were recognised as being quite suitable. Besides, a resin addition of only 0·5 to 1 per cent. of the briquetting material only gives rise to a very small output Since the not very agreeable application of resin was abandoned as soon as practicable, a description and illustration of ball mills may well be omitted here, and in the case of a renewal of the use of resin the corresponding catalogues of the well-known makers of preparation machinery must be referred to.

SECTION V.

SUPPLY, MIXING, AND DISTRIBUTION.

THE small coals or the various kinds of coal to be applied (hard coal, semi fat or fat coals) must be taken from the storage bin or bins in regular definite quantities, according to the requirements of the time, and delivered to the appliance intended for their admixture with the binding material to be used (hard pitch, medium hard pitch, and also resin if necessary), which is simultaneously introduced in the solid form, usually from the fine pulverising machine. The ratio between coal (or the various kinds of coal) and bond which has been fixed for the time must be strictly adhered to, but must permit of being altered at will should circumstances make it necessary.

The usual delivery appliances are:—

Revolving Round Table (Scraping Table) (figs. 21 to 23 and 25).—Such a round table for coals consists of a horizontal cast iron disc 1 to 1·6 metre diameter, fixed to a vertical axle, arranged centrally under a storage hopper or the funnel-shaped lower portion of a large storage bin at a definite distance from the neck of the funnel. The disc is set in rotation slowly by a pair of bevel wheels attached to the transmission shafts below. In the machine designed by Humboldt and illustrated on p. 72, the distance between the disc and the neck of the funnel is fixed by a sheet-metal ring surrounding the lower part of the funnel, from which it is suspended by means of an angle iron ring and several bolts and nuts. By turning the nuts it can be more or less lowered or raised. If the girdle is close to the disc, the neck of the funnel is closed, and the coal enclosed on the central part of the disc cannot escape. When the girdle is raised, an amount of coal is allowed to escape all round the funnel corresponding to the height of the opening and the angle of slope of the coal. After this condition has been attained, the thrust of the coal from the hopper naturally ceases, unless a vertical laminar scraping knife (see also *c* in fig. 25) is arranged

above the outer portion of the table at a sharp angle of inclination. In consequence of the revolution of the table a definite strip is continually scraped away from the flat cone of coal and is moved towards the edge of the table, where it is allowed to fall off. In fig. 21 the scraper can only be seen to a limited extent (at the left), since the greater part of it is concealed behind the neck of the hopper. The coal is scraped into an inclined metal chute through which it slides into a covered worm conveyor.

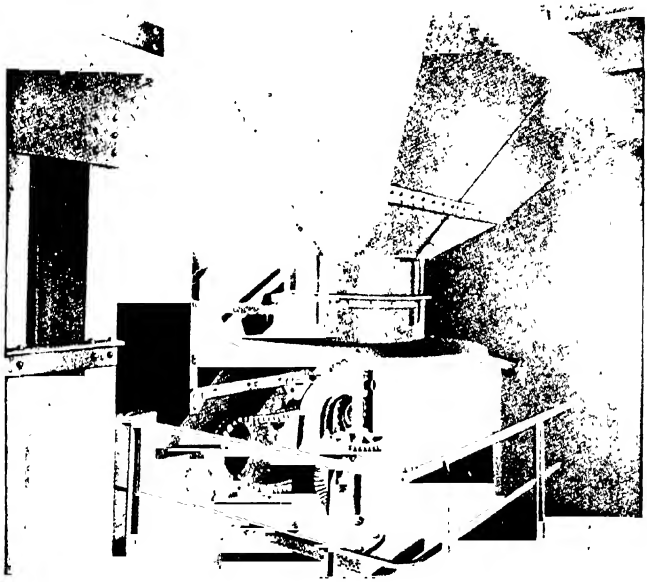


FIG. 21.—Delivery hopper with adjustable girdle, below—revolving round table with scraper. Maschinenbauanstalt Humboldt.

The quantity of coal removed is continually replaced by fresh batches of material from the hopper. This quantity, known as the supply, becomes greater the higher the girdle is fixed, or its distance from the table increased, on the one hand, and the further the scraper is pushed into the coal cone on the other. By the aid of this simple arrangement it is quite possible to regulate or exclude the supply at any moment at will. With large delivery tables, which are very much used, the girdle can conveniently be excluded and only one or more scrapers used in the operations.

The smaller delivery tables for pitch are, on the other hand, mostly fitted with the double regulation, as the above example, or fitted with

slides, etc., since in view of the high price of pitch, an accurate and close regulation of the comparatively small pitch addition (between 5 and 9 per cent of the briquette mixture) becomes of quite special importance.

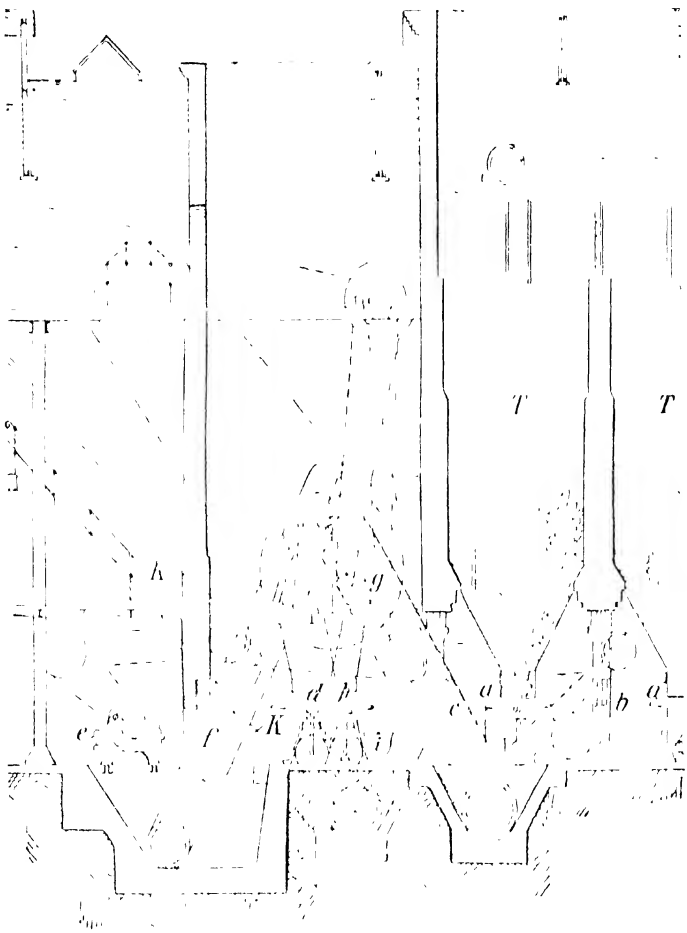


FIG. 22.—Supply, pulverising, and mixing appliances Zeche Hagenbeck

Fig 22 shows the supply, pulverising, and mixing arrangements of the Zeche Hagenbeck's briquette factory, which has already been mentioned several times, and was equipped by Schuchtermann & Kremer in 1906 (compare the complete summary in Section IX.). Under the hoppers T of the three cylindrical masonry coal-storage bins three scrap-

ing tables a, 1600 mm diameter, are arranged so that they can be used altogether in pairs or singly according to requirements, and the coal scraped off (mixture of washed small coal and dry coal dust) delivered on to a common scraper band b running alongside the tables. This conveys the coal into the pit of a large elevator c, which raises it and shoots it into the coal hopper, under which is situated a revolving disc d of 2000 mm diameter. In the meantime the pieces of pitch are broken in the stone breaker e, elevated by the small elevator f, delivered into the disintegrator g, where it is finally pulverised, allowed to slide into the pitch hopper h, and thence on to the small lower disc h (1400 mm diameter), whose shaft is driven from that of the larger disc d by means of a belt.

Both tables make ten revolutions per minute, and scrape off the coal from the large table and the pitch from the small table into the top end on the middle of the common mixing worm i. The worm, revolving on its horizontal axis at thirty revolutions per minute, conveys both the materials spirally, thoroughly mixes and discharges them into the charging hopper of a conveyor k, which lifts the mixture into the upper room of the neighbouring heating and press houses and shoots it into the hopper l (fig. 23).

Another revolving table is arranged under this coal pitch hopper. By means of two scrapers the mixture is divided during the usual full working capacity in the ratio of the quantities to be treated in the first and the following heating ovens, and in such a way that the supply for the first oven o_1 is led directly by means of a chute n, while the remainder is delivered on to a conveyor p, which distributes it to a second and third oven. Fig. 24 shows how the middle oven o_2, which has to supply four presses, is provided for by means of an inclined scraper which does not quite reach to the conveyor; the excess of the briquetting material is carried away under the scraper to the third heating oven o_3.

At the Zeche Blankenburg[1] the various supply arrangements illustrated in fig. 25, and which are somewhat different in arrangement and design, are applied. The necks of the hoppers of both the coal- and pitch holders a a reach to the revolving disc, and are provided at the side with a delivery opening fitted with a movable slide.

The material delivered is led by means of the scrapers c c, which are attached close and tangentially to the neck of the hopper, into a common mixing worm (not shown in the figure) situated between the

[1] *Niederrhein-Westfal. Sammelwerke*, vol. ix., 1905, p. 613, fig. 288.

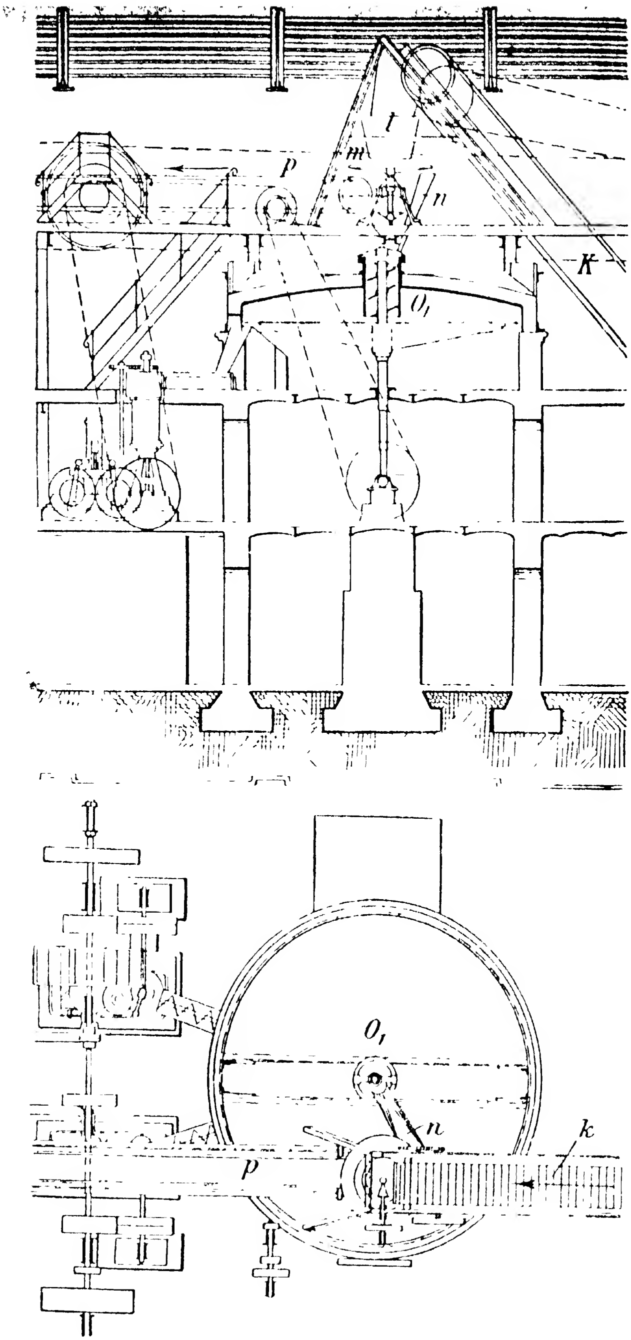


FIG. 23.—Coal-pitch hopper with distribution table and conveyor for supplying heating ovens at the Zeche Hagenbeck. Section and plan.

tables, the tables revolving in opposite directions because of the bevel-wheel drive. However, the material has to pass a second so-called

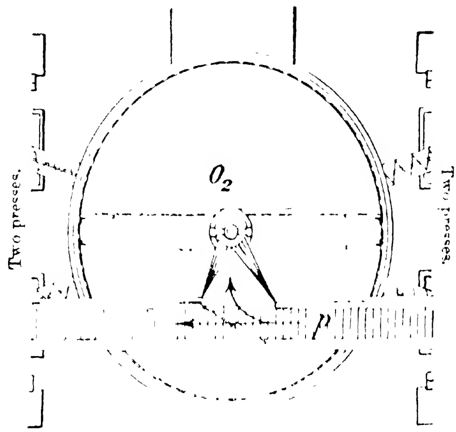


FIG. 24. Distribution of briquetting mixture to several heating ovens by means of a conveyor. Plan.

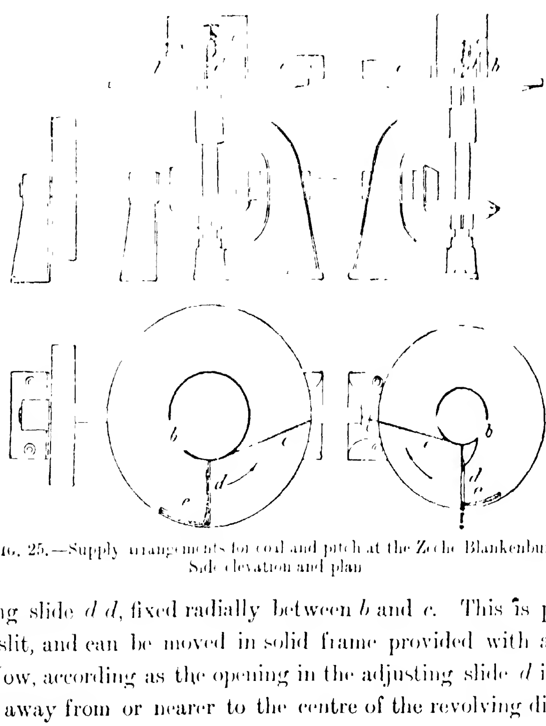


FIG. 25.—Supply arrangements for coal and pitch at the Zeche Blankenburg. Side elevation and plan.

adjusting slide *d d*, fixed radially between *b* and *c*. This is provided with a slit, and can be moved in solid frame provided with a similar slit. Now, according as the opening in the adjusting slide *d* is moved further away from or nearer to the centre of the revolving disc, more

or less material is dragged by the solid scraper *c* into the mixing worm, corresponding to the increase or decrease of the amount of material passing the opening in the regulating slide. The bent sheet-metal arms *e e* attached to the slide frames *d d* only serve the purpose of holding the material issuing from the neck of the hopper together and preventing its being removed too early. This complete appliance

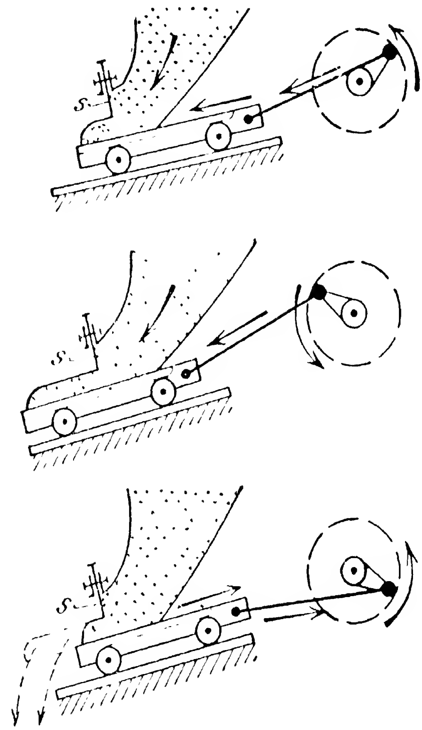


Fig. 26.—Supply of coal by means of rolling slides, represented diagrammatically in three positions.

obviously permits of an extremely accurate regulation of the supply of both materials.

Rolling Slide (supply shoe), figs. 26 and 27, has been copied from the supply arrangements used for a long time in Humboldt's ore-washing plant. Below each hopper-shaped delivery section of the coal-storage tower an iron roller slide or delivery shoe runs across the direction of the length on two somewhat inclined rails, and is slowly pushed backwards and forwards by means of a connecting rod and a crank. The height of the coal layer carried out of the mouth of the

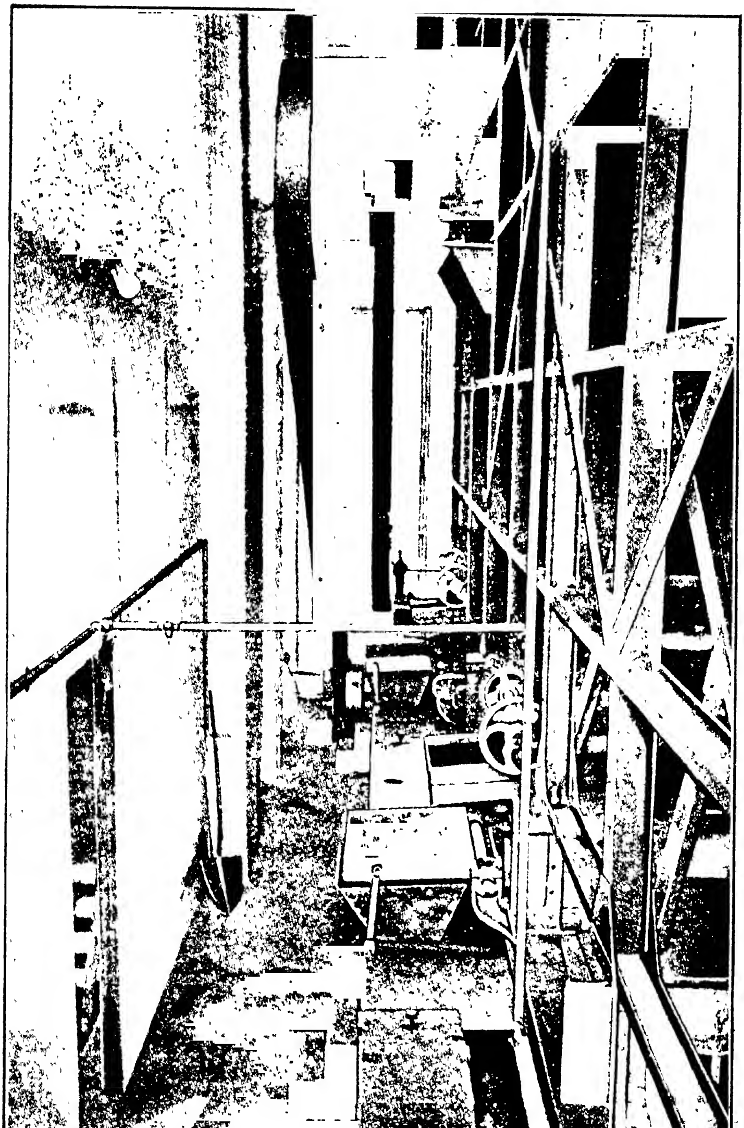


FIG. 27.—Delivery shoe and shaking sieve in the coal storage store of the Rhenau briquette works.

hopper by the roller slide can be regulated by a slide fixed at right angles to the opening and operated by means of a hand wheel. When the shoe travels forwards (fig. 26, I and II) it carries with it the coal which has fallen upon it from above up to the height of the free opening of the slide, the space thus arising under the hopper and covered by the back portion of the slide becoming filled by the mass of coal sliding from above. On the return motion of the shoe, however (III), the plate is drawn away from the mass of coal standing upon it up to the back wall of the mouth of the hopper, and the front part of the accompanying layer of coal as long as the return stroke of the shoe falls on to a shaking sieve (see fig. 27) and thence into a covered worm conveyor and mixer running the whole length of the delivery slides in that particular section of the tower. The shaking sieve has the object of loosening the coal, but principally to hold back the foreign bodies, such as pieces of iron which are introduced during the filling of the storage bins, an appliance which is absolutely essential where foreign coals obtained from external sources are worked up, such as, for example, at the Rheinau briquette works.

For the pitch additions this delivery slide appliance, although occasionally applied, is not so suitable, since a very narrow hopper opening must be used, and consequently it often happens that the material to be delivered does not slide down in sufficient quantity. Further, the pitch very easily adheres to the slide in the warm summers, giving rise to disagreeable interruptions in working.

Supply and Mixing Appliances for Hot Soft Liquid Pitch. At some works (Zeche Holland III, IV, Rheinau briquette works) the pitch is mixed with the coal as soft pitch in the liquid form. The appliances serving for the collection, conveyance and heating of this pitch have already been briefly described above (see p. 57). In addition the method of supply and admixture will be dealt with in the following pages.

The fluid pitch runs from a common tank into a vessel, where it is raised to the necessary temperature by means of a steam coil and a stirrer until, after steady stirring, it remains liquid without frothing. Under the vessel is an apparatus (fig. 28) which permits, by means of a number of lever arrangements, a definite quantity of pitch to flow into an open trough (Zeche Holland III, IV), or, as in fig. 28, through a closed tube (Rheinau briquette works).

The trough or tube opens out below the revolving scraper disc of the coal-supply hopper, which is provided continually with dried small coal from the exit of a revolving drying drum arranged laterally above

it, and every opening lies where the scraper, which can be moved by means of a steering lever with a clamping arrangment, pushes the coal over the edge of the table. At this point the coal unites with the liquid pitch.

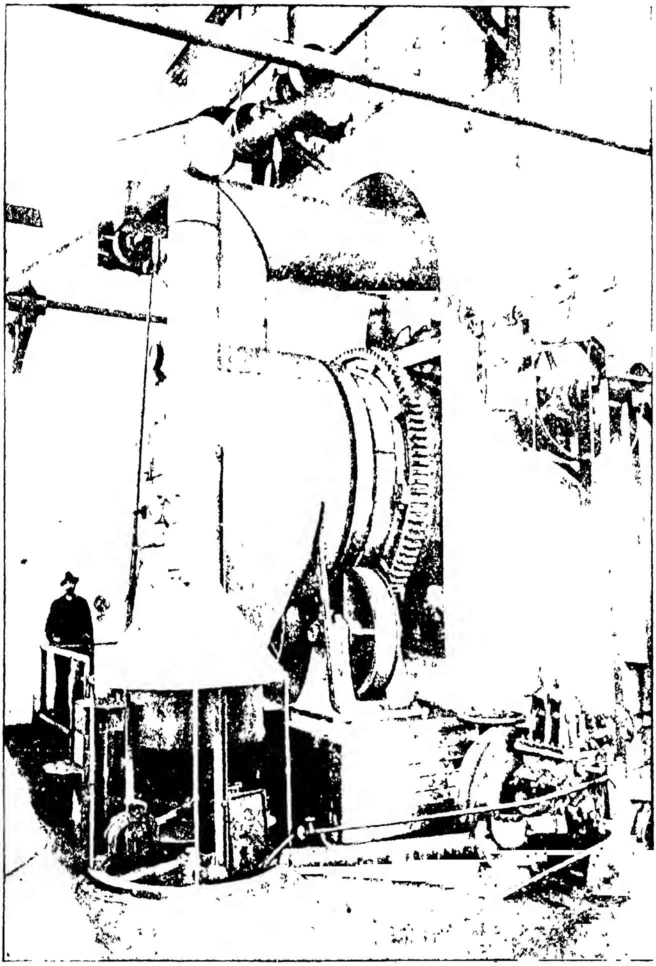


FIG. 28.--Supply and mixing appliances for dried small coal and liquid pitch.

At Rheinau, however, the pitch does not flow into the coal as at the Zeche Holland III. IV., but it is converted in the state of fine dust with the help of a steam jet whose steam-supply pipe and stop-cock can be seen clearly in the picture (fig. 28).

The coal-pitch mixture so produced falls into a flat cylindrical tank, situated in front of and below the disc and provided with a stirrer which produces an intimate mixture and delivers it into the pit of an elevator. This lifts the mixture into a worm conveyor for further transport to the steam kneading machine of the Tigler presser, which will be further described below.

The steam rising from the coal hopper, scraping disc and stirrer is led into a flue running lengthwise above the drying drum, by means of a hood and a line of sheet metal tubing. From the flue the furnace gases utilised for drying the coal and the steam evolved are continually drawn off by means of a ventilator.

Worm Conveyors and Mixers. Worm conveyors are used in this section as well as in the sections dealing with the conveyance storage, and pulverising of the raw materials and have already been represented or at least indicated in several diagrams (figs. 15, 16, 22, and 27). They are to be found in almost all briquette factories and along with band conveyors and elevators form indispensable parts of the equipment. They adapt themselves to the horizontal and inclined conveying of fine grained or floury materials and especially to the mixture of several given materials such as for example the various kinds of coal (hard smithy or semi fat and fat coals) or coal and pitch since the various materials are thoroughly mixed up during the forward thrust in the worm trough and the longer the distance conveyed the more thorough the mixing.

It would appear to be advisable therefore to go more fully into the design etc. of the worm conveyors. Since however they find a much more extensive application in the briquetting of brown coals, it would appear to be more advisable to deal with them in Part II.

SECTION VI.

WARMING, DRYING, KNEADING, AND HEATING.

According to the description of the usual methods of briquetting coals given in Section II. (pp. 49 50), it is first necessary to distinguish —

(*a*) Appliances to deal with moist small coal alone, and

(*b*) Appliances to deal with the mixture of moist coal and pitch; for the purposes of heating up and drying

In addition, it is necessary to deal with —

(*c*) Appliances for kneading and heating the briquetting material; in which order they are dealt with in the following pages.

A. WARMING AND DRYING APPLIANCES FOR MOIST COAL ALONE.

I Steam drying tables,

II Fire drying drums,

must be considered principally for these purposes.

I. Steam Drying Tables.

Steam drying tables have already been applied by the Zeitzer Eisengieszerei und Maschinenbau-Aktiengesellschaft of Zeitz ten years ago for the drying of wet earthy-brown coals, and since that time have been applied in almost all the briquette factories in Central Germany, Rhineland, etc., built by this well-known firm. Recently the coal-briquetting factories in the kingdom of Saxony and Silesia have been similarly equipped by the same firm. Steam drying ovens of correspondingly smaller size can also be used for the drying of washed small coals.

The Zeitz Steam Table Dryer is illustrated and fully described in Part II. among the drying ovens for brown coals. Here it will only be

stated that it consists of a system of hollow iron plates arranged one above the other, with a clear space in the centre and discharge openings either at the inner or outer edges.

The tables are provided with revolving stirrers consisting of metal shovels which wind the thin layer of coal charged from above alternately from the inside to the outside of one table and from the outside to the inside of the table immediately below, and finally discharge the coal from the lowest table. The hollow tables are heated by the exhaust steam from the engines and presses together with fresh steam when required, introduced through two hollow columns standing opposite to each other, while the condensed water flows away through two other columns (see figs 29 to 31). In this way, aided by the constant stirring, the water present in the coal is gradually evaporated and let into the open as "Brasen" (Wrasen) through a vapour flue attached low down to the drier. The coal is, in addition, thoroughly mixed by the constant stirring.

Drying ovens with eleven tables suffice for the drying of washed, drained small coals containing about 15 to 20 per cent moisture down to about 4 to 5 per cent residual moisture, using the customary 5 m. diameter tables with a central space of 2 m diameter

According to the experience gained at the Freiherrl. v. Burgker Steinkohlenwerken at Dresden,[1] the life of a steam table oven for hard coals is only about six years

A Zeitzer table oven for reducing 15.3 tons small coal with a water content of 20 per cent to 13 tons with 5 per cent water, weighs about 110,000 kg and costs at the works about 37,000 marks.[2]

The Zeitzer Eisengieszerei has recently turned its attention to the manufacture of special drying drums for pit coals, and these will be dealt with more fully below.

Busse-Tigler System of Steam Drying Tables[3] (figs 29 to 31).—The Maschinenbau-Aktiengesellschaft Tigler in Duisburg-Meiderich, who supplied the first briquette factories built by them with the Petry & Hecking drying drums described below, have recently taken up the construction of special steam drying plates for coals in addition to the building of briquette presses, and have already completed seven such appliances for four new plants, two of which are for the Kgl. Berg-

[1] This briquette factory is described and illustrated below in Section IX

[2] According to a statement made by the Zeitzer Eisengieszerei und Maschinenbau-Akt.-Ges. in the spring of 1908

[3] The arrows indicate the direction of motion of the coal.

inspektion Konigshutte O S briquette factory.[1] At the present time (summer 1908) four more are in the course of construction.

The design of drying oven described as the Busse-Tigler system is similar in general and in many details to that of the Zeitz apparatus,

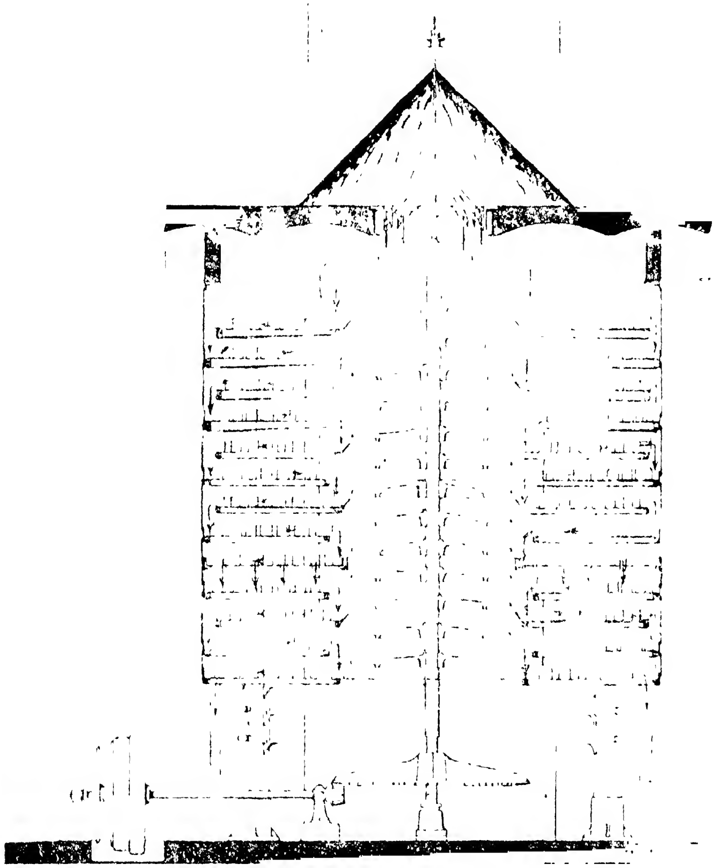


FIG. 29. Steam table drier for coals. Busse-Tigler system. Vertical section.

but differs from it principally in a peculiar improvement of the steam tables (Patent No. 189451, Group II). The hollow space filled with steam—when the table is in the horizontal position—is made slightly conical towards the circumference of the table on the lower side, so as to permit of a free and rapid removal of the condensed water, thus increasing the efficiency. Further, the coal which is being moved over

[1] Stea[illegible] plant is described and illustrated in Section IX.

[illegible] among the dry[illegible]

the table is not allowed to fall through sundry covered openings, but simply falls over the inner or outer edge of the table on to the one below. Consequently, the tables are of alternately large and small diameters, and the edges on to which the coal falls from the table above are provided with sheet-metal edges high enough to prevent pieces of coal from falling away. One table (fig. 29, fifth from the bottom) is like the Zeitz apparatus, inlaid with sheet-metal sieves, which holds back and pushes over the edge by special means all large

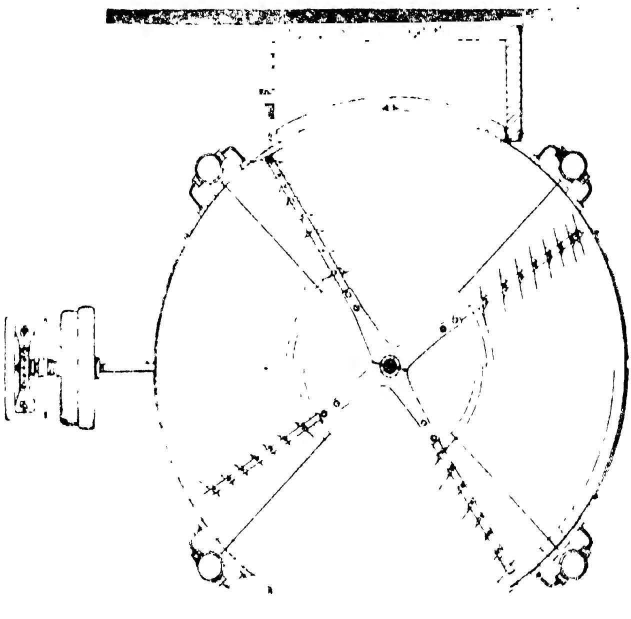


FIG. 30. Steam drying tables. Burre Tyler system. Ground plan.

foreign bodies, such as pieces of iron and wood, while the coal falls through the square holes of the sieve.

The stirring arms of the vertical stirring shaft are fitted with sheet-steel shovels, which are suitably inclined for moving the coal from the inner to the outer edges, or *vice versa*. The coal is delivered centrally on to the first table, and the amount can be accurately regulated by means of a movable metal cylinder. By means of a friction coupling the stirrers can be thrown in and out of gear while the belt is running. The driving belt runs on cone pulleys. A sheet-iron cover consisting of hinged doors surrounds the complete oven down to the supplementary vapour flue. Generally the vapour flue opposite to one or several

of the lower doors is left open, to promote the drying of the coals and the removal of the vapours by the stream of air entering from the outside. Further, the doors allow the oven attendant to take samples

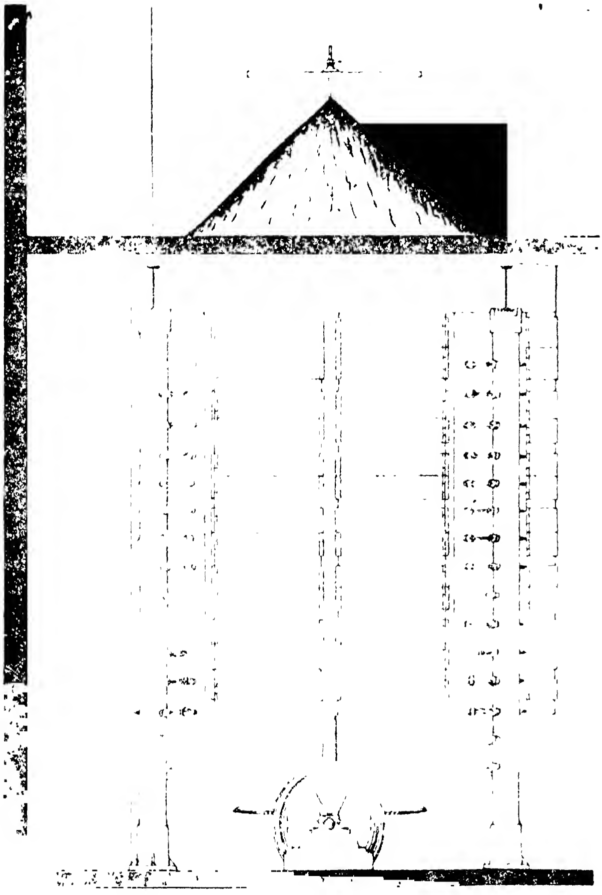


FIG. 31.—Steam drying table. Busse-Tigler system. Side view.

during the operations at any desired place in order to make tests of the moisture content of the coal.

The lower tables are provided with ventilators, so that the process may be regulated exactly at any time for the production of coal with the most desirable content of moisture and at a suitable temperature for briquetting.

From the last table the dried coal is carried out into a charging

hopper or a worm conveyor through several (up to four) discharge tubes (fig 29). In general, steam drying tables for coals have the following advantages:—

1. Dangers from explosions and fire volatilisation, and depreciation of the coal by overdrying are excluded
2. Accurate regulation of the source of heat, with a resulting constant residual moisture content and temperature of the coal
3. Lower costs of heat owing to use of exhaust steam.
4. The power required is moderate
5. Easy to attend several driers can be supervised by one attendant
6. Simple arrangement of the whole plant

These advantages according to the experiences of works where steam drying tables have been in use for a long time, are opposed by the following disadvantages:—

1. Considerable wear of the upper table, occasioned by the coal striking it in its fall, the coal being as a rule much harder than ordinary earthy-brown coal. The result is that the upper tables must often be renewed, causing extremely high costs and unwelcome interruptions in the working
2. Rapid destruction of the numerous stirring shovels, which often have to be renewed after a few months
3. Very great weight, high first cost, and heavy costs of freightage and installation

II. Drying Drums heated by Fire.

These were first introduced into coal briquetting plants by the Maschinenbau Aktiengesellschaft Tigler in the shape of the "coal drying and mixing apparatus" built by Petry & Hecking in Dortmund. Such appliances were supplied to, among others, the briquette factory of the Zeche Holland III IV, erected at Wattenscheid in 1903, and the Rhenau briquette works, which were built about the same time but have been much more often cited. Both works use soft pitch as binding material, which is added in the liquid state to the previously dried small coal mixed and heated in a drying drum.

As previously mentioned the Zeitzer Eisengiesserei has recently taken up the construction of fire-heated drying drums according to a system of their own.

Petry & Hecking Fire-heated Drying Drums (figs. 32 to 34).—This coal-drying and mixing apparatus is on the whole of similar con-

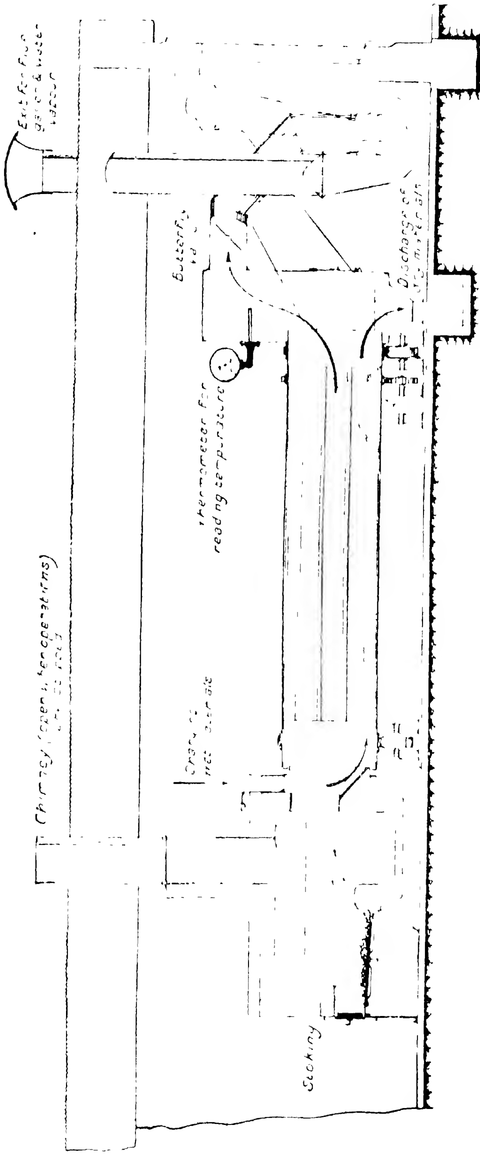
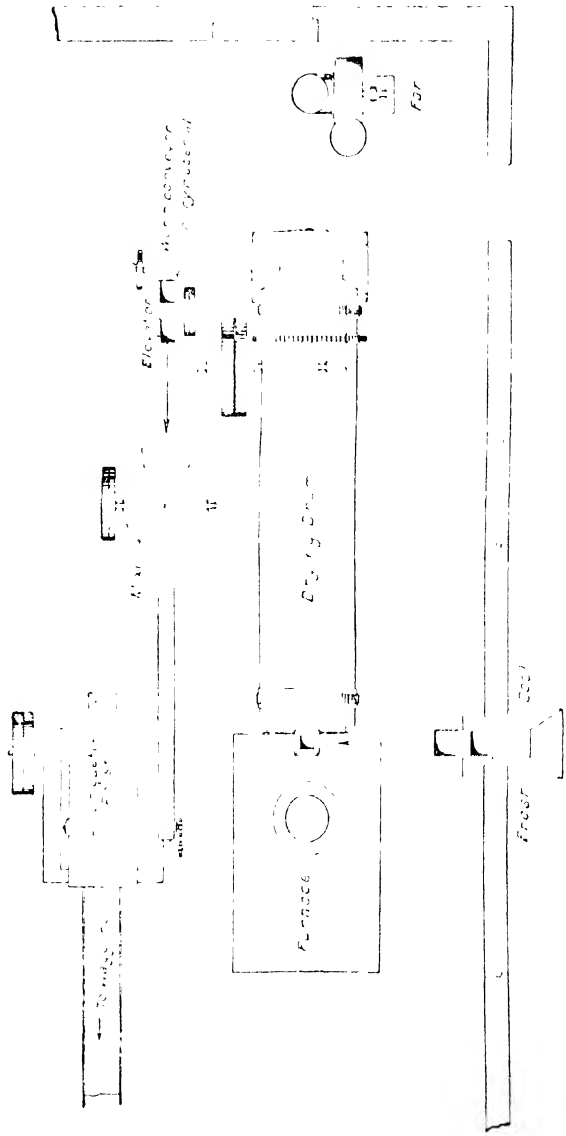


Fig. 32 —Fire-heated drying drum for coals. Petry & Hecking Longitudinal section.

struction to the drying drums supplied for many years by the same Dortmund firm for drying rape cuttings and so on. It consists of an

iron drum about 10 m. long and 1700 mm diameter, arranged horizontally on rollers at both ends so that it can be revolved slowly (about 10



revs per min.) by means of a gear-wheel and a toothed wheel surrounding the drum.

FIG. 31. —Discharge end of a drying drum by Petry & Hecking, with coal and pitch distribut
(Rheinau briquette works.)

Six to eight angle irons extending the whole length of the drum, are riveted to the inner wall. The drum is open at one end and closed at the other.

At the open end a furnace with plain grate firing is built externally and the fire is principally fed with waste from the briquette factory. The firing can be provided with an induced undercurrent of air, as is done at the Zeche Holland III. IV., by means of a fan.

The closed end of the drum is connected with an exhauster arranged alongside by means of a rising sheet iron tube and by this means the chimney gases and the steam driven off from the coal are sucked off.

Moist small coal is charged by means of a hopper into the open end of the drum where the fire gases enter at their greatest heat. It falls down a slide on to the inner wall of the drum where it is caught by the angle irons carried up by the steady revolution of the drum, and then allowed to fall again. Like the hot gases the particles of coal are displaced by the suction of the exhauster. Whilst falling, therefore, they are more or less deflected from the vertical in the direction of the draught according to their shape and size and so by the continual repetition of these operations they are gradually moved along the whole length of the drum until discharged at the closed end (see also fig. 34). In this way complete drying is effected.

The fine coal dust produced is carried away in the flue gases. In order to catch it and turn it to account the exhauster at many installations (Zeche Holland III. IV. and so on) is made to blow the exhausted mixture of gases, steam and dust through a sheet iron tube into a so-called dust catcher.

At the Zeche Holland III. IV.[1] the mixture is led through a side opening into the upper part of a tall sheet iron cylinder which constitutes the dust catcher. Above this point is a fine meshed sieve, covered with a layer of coke and gravel steadily sprinkled from above by means of a fine water spray. In this way the particles of dust are deposited from the stream of gas and are led away with the shower of water through the funnel shaped bottom of the cylinder into a tank, while the waste gases and steam escape into the open through the filter bed at the top. The coal mud is removed from the tank by means of a rotary pump into the drainage tower of the washing plant, sent on to the coal-storage tower for coking coals, and finally worked up with the latter for coke.

[1] *Niederhein. Westfal. Sammelwerke*, vol. ix., 1905, p. 647.

At other installations the dust-catcher takes the form of a rectangular wooden tower (dust-extracting tower), provided, instead of a sieve, with a double layer of grate bars carrying a filter bed sprinkled by means of a powerful spray.

Regulating Appliances. The temperature of the escaping heating gases[1] is read off by means of a thermometer fixed to the side of the closed end of the drum, while above this a depression meter attached to the conducting pipe serves for observing the suction of the exhauster.

For regulating the temperature and pressure according to the varying moisture content of the coal, a slide arrangement is provided at the open end of the drum, by means of which the opening through which the fire gases enter can be made wider or narrower, while a throttle-valve is placed in the leading pipe of the exhauster. Excessive fire gases escape through a small flue attached to the fireplace.

Naturally, the exhauster must not suck in any outside air. In order to prevent this, the charging hopper for the wet coal as well as the discharge chute for the dried coal is provided with a hinged valve, which is opened by the weight of the falling coal, but is automatically closed by an external counter-weight when there is too little coal.

Testing of the Petry & Hecking Drying Drum.—According to previous experiences, this drying apparatus does not appear to have been specially tested for the drying of coals. Since the forward motion of the coal alternately lifted and allowed to fall by the revolution of the drum is, on account of the horizontal position of the latter, solely effected by the suction of the exhauster, this must be made so great that the coarsest and heaviest grains of the coal are deflected from the vertical line of fall. With coals containing little water this easily leads to overdrying, especially of the finest and lightest particles, and to the formation of coal dust, which is carried away in the stream of gas to be deposited, by the aid of water, in a dust-catcher, whereby it is lost for the purposes of briquetting. This necessitates the troublesome removal of coal slimes, with its not inconsiderable costs, and, in addition, it may be taken that, in the case of overdrying, a certain amount of gasification of the coal takes place in the drum.

In any case, undivided attention must be given to the working of the drum apparatus in order to avoid loss and to obtain the correct degree of dryness by aid of the regulating appliances described. In a

[1] At the Zeche Holland III/IV. this temperature usually amounts to about 80° C.

modern briquette factory an experiment has been made to move the coal forward without the suction of an exhauster, by means of angle-irons wound spirally round the inside of the drum The results were favourable, but only so long as the moisture content of the coal supplied did not exceed a certain limit. With a high moisture content the coal was carried much too quickly through the drum and was not dried sufficiently.

Fire-heated Drying Drum. *Zeitzer Eisengiesserei Patent* (figs 35 and 36) –This new apparatus, constructed by the Zeitzer Eisengiesserei und Maschinenbau Akt.-Ges., is an improvement on the Petry & Hecking drying drum, and consists principally of a furnace *a* for the development of hot gases, of an external fixed drum *b* with a revolving drum *c* inside it, the gas conducting pipe *d*, the central gas leading tube *e*, the head *f* with the outfall *g* the dust separator *h*, and the driving gear for the inner drum *c* situated at the back

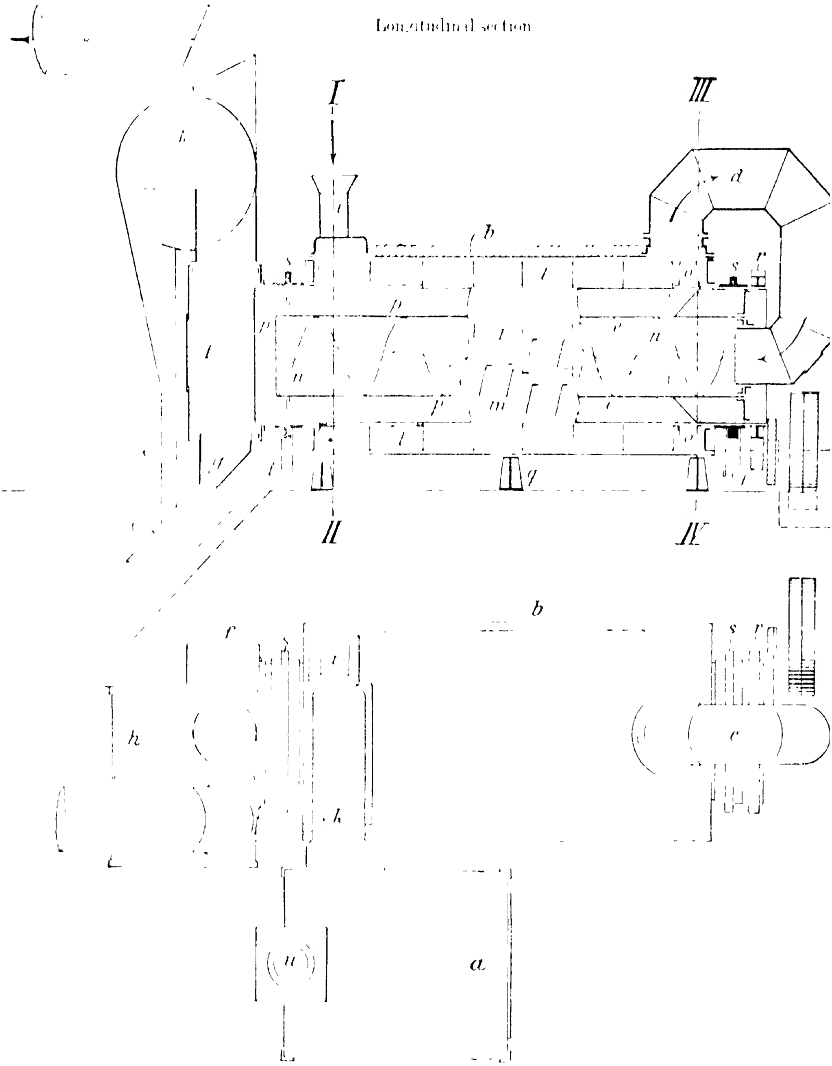
The cold wet coal falls at the front through the tangentially arranged charging hopper *i* (see longitudinal and cross sections I II) into the outer drum *b*, *i e* into the space between the drums *b* and *c*, while the fire gases are led into this space through the opposite side from the furnace *a* by means of the channel *k* The coal comes therefore into immediate contact with the hottest gases The surface of the revolving drum *c* is fitted with shovels *l*, which continually lift up the material at the bottom, carry it through the gases travelling from the rear, and spread it out on the upper portion of the cover at the top. A space of about 13 mm is left between the shovels *l* and the inner surface of the outer drum *b*. At the same time the coal is conveyed in the direction of travel of the gases towards the back end of the apparatus by means of the flat transport irons *m*, which are connected with the shovels *l*

The gases are led into the central tube *e*, with the object of giving up more of their heat, by means of the leading tube *d* A light sheet-metal spiral is built into the tube *e* to give the gases a rotary motion, and in this way separate the accompanying heavy particles of dust during the passage.

The heated and already partially dried coal conveyed towards the rear end of the apparatus is delivered into the inner drum *c* by means of the sheet-iron shovels *o* (see cross section III–IV. and longitudinal section), where it is further dried by conduction and radiation, and the motion towards the outfall *g* is provided by the constant revolution of the transport angle irons *p* (see section I.–II.).

The openings through which the material is introduced by the conveyor shovels *o* are closed by freely self-acting valves after the

Longitudinal section



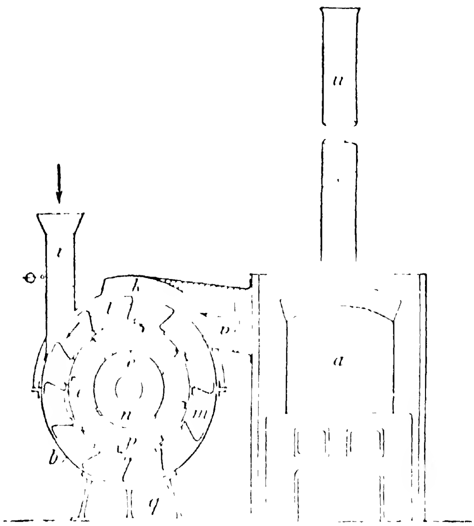
Plan.

FIG. 35.—Zeitz drying drum for coals. Longitudinal section and plan.

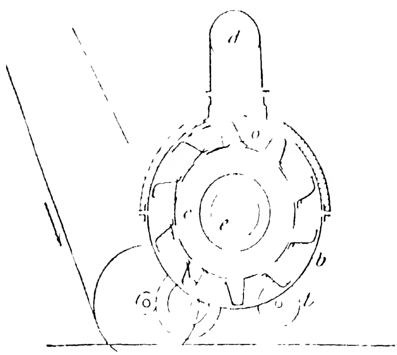
shovels are emptied, in order to prevent as far as possible the too previous entrance of the gases into the inner drum *e*.

Dried to a water content of 4 to 5 per cent., the hot coal falls

finally through the outfall q into the pit of an elevator. The exhaust gases along with the steam on their way to the chimney pass first through the dust separator h, which frees them as far as possible of all dust.



Section I. II.



Section III. IV.

Fig. 36.—Zeitz drying drum. Sections.

The outer drum is made in two parts, so that the upper half can be lifted off. The lower half is provided with large cleaning doors at both sides, which at the same time permit of a convenient changing of the shovels, etc. The fixed outer drum rests on two different bearings g, of which only one is fixed in consequence of expansion.

The drive of the inner drum is effected by means of fast and loose pulleys and corresponding gear-wheel transmission In addition to the encircling toothed wheel *r*, the drum is provided with two strong runner bands *s*, running on four powerful friction rollers *t*.

A chimney *u* with a throttle-valve is provided for regulating the temperature of the furnace. It is also used during the process of working, when the passage slide *v* must be kept closed (section I.–II.). Further, it is important that a self-acting inclined valve should be placed in the downfall under the coal-supply hopper *i*. When the weight or downward pressure of the coal falling on the valve exceeds that of the counter-weight placed outside, the valve opens downwards and allows the coal to pass through. When there is insufficient coal on the valve the counter-weight immediately closes it In this way the otherwise easy passage of the fire gases streaming from the canal *k* through the opposite chute for the introduction of the coal is prevented

The Zeitz drying drums are constructed in various sizes for an output of 5 to 50 tons of dried coal per hour. For drying 15.3 tons coal containing 20 per cent. moisture to 13 tons containing 5 per cent moisture per hour, the necessary drying drum would weigh about 26,000 kg., and the cost at the works would be about 17,000 marks, that is, 84,000 kg and 20,000 marks respectively less than the weight and price of a Zeitz steam table drier [1] of equal capacity a ratio which is very largely in favour of the drying drum

It must be added, however, that the wear of the latter is very much less The wear occurs principally on the shovels, which are consequently provided with renewable scoop edges These can easily be renewed by opening the side doors without necessitating the removal of the other parts in front. In other respects the practical results must be awaited.

B. HEATING AND DRYING APPLIANCES FOR COAL AND PITCH.

In the apparatus of this description in use at the present time—the so-called heating ovens with revolving tables—the heating, etc., of the mixture of coal and pitch is effected by direct firing.

Heating Oven with Revolving Table (figs. 37 to 39).—This oven, first introduced by Biétrix & Co., finds application at a large number of

[1] According to a statement of the Zeitzer Eisengiesserei, spring 1908.

briquette factories in Germany and other countries working with Couffinhal presses. It is in the first rank for heating and drying wet or washed coals, as well as for the softening of the intermixed pitch, and is also suitable for dry coal so long, as is generally the case as it contains at least 4 to 6 per cent. hygroscopic water (partly derived from underground irrigation).

The heating oven dries the coal in very short time down to between 1.5 and 2·5 per cent., heats it up until the tar softens, melts the intermixed pitch, mixes it thoroughly with the coal, and in this way prepares the coal pitch mixture for briquetting and renders possible the preparation of superior briquettes with the least possible amount of binding material.

As will be seen from the views of the ovens given in the section on Supply, Mixing, and Distribution (figs 23 and 24) and from figs 37 to 39, the heating oven consists principally of a slowly revolving cast-iron round table, the appliances for the supply, turning, displacing, and scraping of the briquetting mixture, the fireplace with the flue outlet, and the brickwork with the iron stay rods surrounding the whole.

The circular table built up of twelve plate cast-iron segments, is fixed on a vertical shaft, which is set in slow rotation by means of a pair of bevel wheels geared with each other below (figs 23 and 38). These also set in motion the supply and kneading appliance, which is to be found above the table. It consists of an upper portion, with wrought-iron wings arranged spirally round the axis of the table, and a cast-iron cylinder passing through the flat oven vault, carrying a stay for the upper bearing of the shaft and opening out about 6 to 8 cm above the surface of the table. The mixture of pitch and coal introduced into the cylinder is taken up by the wings with every revolution of the axis, kneaded, and conveyed downwards until it falls upon the table. By means of the turning and displacing appliances, combined with the revolution of the table, the mixture is gradually moved from the centre outwards over the whole surface of the table with constant turning and mixing, while by remaining in the oven it becomes uniformly heated and dried. This is assisted by a number of horizontal and radial iron bars, arranged above the table in the older arrangements six, now five (see fig 37), with adequate equipment

Their inner ends are fixed in the supply cylinder, while the outer ends rest in openings in the furnace, framed with cast iron boxes and closed by doors. Four of these iron bars have screwed into them rake-

shaped bolts, whose lower ends, flattened out into triangular shape, reach almost to the table in an inclined position, so that they are able to turn the coal and pitch mixture over and over. The fifth iron bar (near the longitudinal section I.–II.) is connected with a movable iron rod by vertical and inclined metal strips, very much in the manner of a venetian blind. The movable iron bar ends in a spindle at the right, which passes through a fixed nut and carries a handle outside the furnace.

Each of the strips acts in such a manner that the mixture of coal

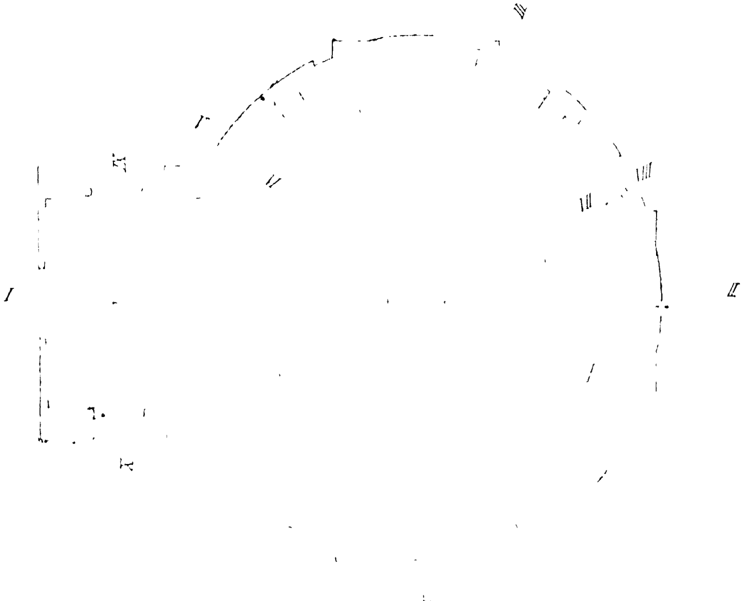


Fig. 37.—Heating oven with revolving table for three presses.

and pitch brought to it by each revolution of the table is displaced towards the outside. In this way the mixture travels from the centre to the edge of the table after a certain number of revolutions.

According as the metal strips are more or less inclined by means of the handle and spindle, the mixture remains a shorter or longer time on the table. The thickness of the layer over which the fire gases pass on the table is also regulated in the same way. The scraping of the briquette mixture from the table is effected in the same manner as in the previously described delivery tables—by means of inclined scraping plates, which project from the various discharge openings of the oven, the number of which depends upon the number of presses to be supplied.

Figs. 23 and 24 show heating ovens for two and four, figs. 37–39 an oven for three, presses; section III.–IV., fig. 38, passes through two delivery openings opposite to each other. The scraper plates (not represented) are provided, in the part passing out of the furnace, with a suitable slot, through which passes a spindle with a wing nut, and fastened to the furnace wall. By this means the scraper plate can be clamped in a more or less forward or backward position. The material coming into contact with the scraper glides along it and falls into a worm conveyor, one end of which is situated under the discharge opening of

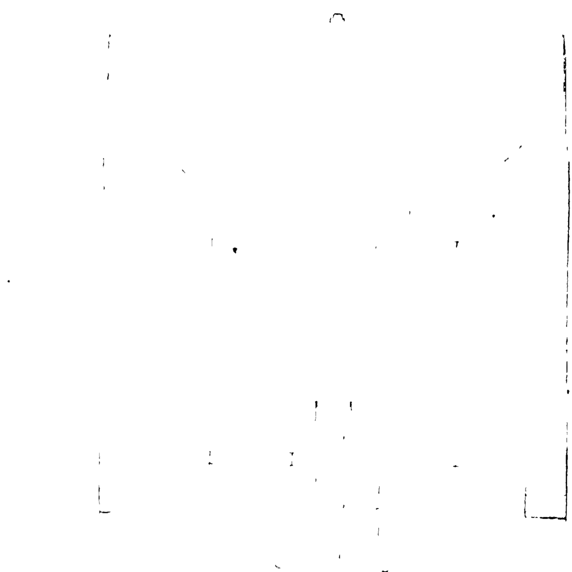


Fig. 38.—Heating oven. Vertical section through two discharge openings.

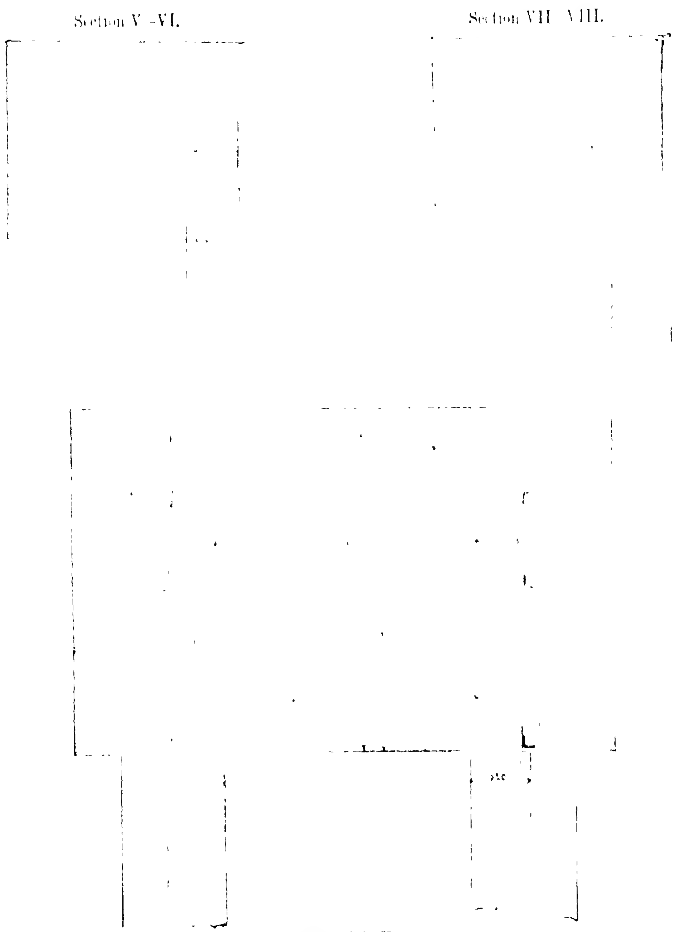
the oven, while the other is situated near the steam kneading arrangement of the corresponding press.

The mixture discharged during the normal working of the oven has a temperature of about 90° to 95° C., according to the content of water, and must feel sandy. The mass only becomes tacky and plastic after gradually cooling to about 80° C. in the steam kneader.

The side fireplace (figs. 37 and 39, section IX.–X.) contains a grate which can be stoked from both the narrow sides, and is connected with the upper part of the oven by means of a fire bridge.

The lower part of the masonry, carrying and surrounding the fireplace and the oven, is of ordinary brick, while the upper portion is

made of refractory materials. A sheet-iron cover surrounds the masonry work, which is strongly stayed near the fireplace. Generated by burning waste material from the briquetting process on a double



Section IX.-X.

Fig. 39

grate, the flame and hot gases strike the lower side of the flat vault of the furnace and are deflected on to the mixture which is being subjected to continual stirring on the table. The gases then pass through two niches in the furnace wall opposite (right of fig. 37, and fig. 39, section VII.-VIII.), where they are deflected downwards and pass back under the table on their way to the chimney *via* a

vertical brick channel situated in front of the fire bridge. The brick flue is indicated by a dotted line in fig 37. The table is therefore not only heated from above, but is also heated uniformly from below. A smoke slide is hung, in the usual manner, over the head of the exhaust flue. It is lowered when the suction of the chimney has to be interrupted for the purpose of damping the fire, while it chiefly permits regulation of the suction at will by correspondingly varying the area of the flue. Below the table in the masonry of the oven are two manholes fitted closely with iron doors, so that the annular platform (oven wharf) in the interior of the furnace is accessible for removal of flue dust.

The under part of the oven containing the bevel-wheel drive is easily accessible from the bottom of the briquette factory.

Dimensions of Heating Ovens.—The following are the chief dimensions of modern heating ovens:—

Diameter of revolving table . . .	6500 mm.
Clear width of oven above the table .	6550–6600 „
Outside diameter of oven . . .	7175–7300 „
Height of oven to platform . . .	3100–4250 „
Height of oven up to the crown of the upper vault	5700–7075 „
Length of the grate	2250–2400 „
Breadth „ „	1500–1550 „
Resulting area of grate surface . .	3·37–3·72 sq. metres.

Rate of Revolution.—Under ordinary conditions, working up crude mixture containing 10 per cent. water, the oven makes about $3\frac{1}{2}$ revolutions per minute.

Heat of the Oven.—The temperature of the oven above the table must be kept at about 220° to 250° C. in order to evaporate rapidly the water adhering to the coal, to soften the viscous constituents of the coal itself, and melt the pitch, which latter occurs at about 80° to 90° C. or 100° C. Higher temperatures would result in the volatilisation and burning of the heavy oils, etc., contained in the pitch.

Output.—Under the above conditions, such an oven would supply as much briquetting material as could be worked up by a double Couffinhal 3-kg. press, which amounts to about 10 to 12 tons per hour, or 100 to 120 tons in ten hours, of briquetting material containing 1·5 to 2 per cent. moisture, at a temperature of 90° to 95° C.

By the introduction of drier coal, or the discharge of coal not so

completely dried, the output can be increased $1\frac{1}{2}$ to 2 times its magnitude by raising the speed of revolution.

A few calculations are appended here:—

1. How many kilograms of briquetting material containing 2 per cent. moisture can be recovered from 100 kg. of raw mixture containing 10 per cent. water?

100 kg. raw mixture contain	100 kg. of briquette mixture contain
90 kg. of dry material	98 kg. of dry material
+10 kg. of water.	+2 kg. of water.

But from the 100 kg. of raw material, in consequence of the removal of most of its contained water, less than 100 kg. of briquetting material is obtained, the amount being equal to the 90 kg. of dry substance present in the raw product containing a correspondingly less quantity of water. Denoting this quantity of water by x, we get

$$98 . 2 = 90 \quad x$$

$$x = \frac{2 \times 90}{98} \text{ about } 1{\cdot}85 \text{ kg}$$

The heating oven therefore yields from 100 kg. of raw product a briquetting mixture which consists of -

90 kg dry substance
+1·85 kg water

and consequently amounts to 91·85 kg.

The 1·85 kg. water form the required 2 per cent. according to the equation.—

$$91{\cdot}85 . 1{\cdot}85 = 100 : x$$

$$x = \frac{1{\cdot}85 \times 100}{91{\cdot}85} = 2 \text{ per cent}$$

2. How many kilograms of water must be evaporated in the oven from 100 kg raw product with 10 per cent water if the resulting briquette mixture must contain 2 per cent moisture?

The calculation can be made very simply from the preceding one. The 10 kg. of water in the raw mixture are reduced to 1·85 kg. in the briquette material. Consequently, $10 - 1{\cdot}85 = 8{\cdot}15$ kg. water have to be evaporated in the furnace.

3. How many kilograms of the raw mixture must be delivered to the oven for an output of 12,000 kg. briquette material per hour?

From 1 we get the equation:—

$$91{\cdot}85 : 100 = 12{,}000 : x$$

$$x = \frac{12{,}000 \times 100}{91{\cdot}85} = \text{about } 13{,}065 \text{ kg. raw material per hour.}$$

4. Under the same conditions the amount of water to be evaporated per hour is as follows:—

$$13{,}065 - 12{,}000 = 1065 \text{ kg.}$$

Coal needed for Firing.—A heating oven of the given dimensions requires for firing about 1·5 to 2·5 per cent. (an average of about 2 per cent.) of the briquette production of the press or presses which it supplies, mostly in the shape of pressed stones spoiled before or during the loading, and other waste products. About 240 kg., corresponding to about 80 3-kg. briquettes, are burnt per hour in an oven whose output is about 12,000 kg.

The amount of coal used obviously increases with the water content of the raw product, with the decrease in temperature of the material as well as that of the atmosphere, and, further, with the degree of drying of the briquetting material.

Attention.—One worker is required to attend exclusively to each oven. The man has to attend to the firing, to take care that the oven is always at the proper temperature, to see that the mixture does not stay in the oven for a longer or shorter time than is necessary, and to remove immediately the cause of any stoppages.

Prevention and Extinction of Oven Fires.—If the oven gets too hot, which is particularly likely to happen with dry coal, the revolution of the table is accelerated to cause the mixture to travel through and be discharged from the oven as rapidly as possible, while at the same time the gas port is closed by means of the slide and the fire on the grate damped down so as to prevent the ignition of the heavy oil vapours evolved and the consequent burning away of the expensive pitch. If, however, the pitch has already taken fire, the whole of the material in the oven is dragged out as rapidly as possible on to the plaform by means of a special scraper plate passing through an opening provided for the purpose near the grate (figs. 37 and 39, section V.–VI.). The fire is then extinguished by means of water from a hose connected to the water mains of the briquette factory. Under no circumstances must water be played inside the oven itself, as this would lead to an explosion. The coal-pitch mixture drawn from the oven and quenched is not usually put back again, but is more often burnt on the oven grate as waste. With careful attention and the use of a pitch which is not too soft and easily inflammable, oven fires can be almost prevented or at least extinguished in the manner indicated rapidly and without danger.

Use of Oven for Coal alone (without pitch).—At some briquette installations it was found in due time to be more advantageous not to subject the pitch to the direct action of the flame. In such places the oven is only used for drying and heating the coal The pitch is added to the heated coal subsequent to its issue from the oven, both being allowed to fall at the same time into a steam-heated mixing worm which conveys the mixture to the steam stirrer of the press.

This method has, however, not stood up to the test, such a thoroughly intimate uniform mixture of pitch and coal cannot be obtained as by the simultaneous working up in the heating oven Further, the pitch tended to ball up into lumps in contact with the hot coal and to stick to the worm and the press dies. The result was fewer good briquettes and more frequent interruptions of the working This system has, therefore, been given up for the most part.

Limits of Application of the Heating Oven.—Resin, which melts at about 120° C. and easily ignites, cannot be introduced into the heating oven. When, in consequence of high prices, pitch is partly replaced by resin (see pp 41 and 42), the resin must be added to the heated mixture of coal and pitch discharged from the oven in the worm conveyor between the oven and the steam kneader.

Binding materials in the liquid form, such as liquid soft pitch, tar etc., must also be kept well away from the heating oven They can only find application when the coal is dried and heated alone The mixing of coal with liquid pitch or tar takes place in the ordinary steam kneader, as described and illustrated in the following pages.

C. APPLIANCES FOR KNEADING AND HEATING.

Of these, steam kneaders occupy the first place, partly in combination with a steam superheater.

I. Steam Kneaders (Steam Stirrers, Fr. Malaxeurs).

Steam kneaders are attached to most briquette presses and usually directly connected. They are used either (1) as single or principal appliances, combined with steam superheaters, for heating, stirring, mixing, and kneading the mixture of coal and pitch, or (2) as intermediate and subsidiary appliances placed between the heating and drying ovens on the one hand and the press on the other, and only have the object of continuing the work of the oven, *i.e.* immediately to prepare for pressing the previously dried, heated, and thoroughly

mixed material delivered to it. Steam kneaders of one and the same class show certain differences with regard to size, arrangement, and working, partly corresponding to their various uses.

The following is common to them all :—They consist of a cylindrical sheet-iron cylinder Z standing on cast-iron beams (figs. 40 and 41) through the centre of which passes a revolving shaft W with radial wings, arms, or knives *f*, arranged spirally for stirring, kneading, and pressing downwards the coal-pitch mixture supplied, the whole being set in rotation by means of a pair of bevel wheels below. The cylinder is usually open at the top, where it receives the mixture conveyed to it continually by a worm conveyor or mixer which opens out at this point. Below, the cylinder is closed, but is provided at the side near the distributor with a square opening—or with two openings for two presses—which serves for the removal of the mixture when ready, and can be closed at will by a slide *s* provided with a hand lever, a crank lever *h*, and a regulating wheel *r*. About the inside cylinder wall short conical jets *d* are arranged spirally, corresponding to holes in the cover, where outside connection is made with the steam mains, and in this way superheated steam or high pressure steam from the boilers is allowed to impinge on the mixture. The steam finally escapes into the open at the top either direct or through an exhaust pipe.

1. Large Steam Kneaders (with Steam Superheater), figs. 40 to 42 are applied at places where there is no heating oven,[1] and like the latter therefore they receive the cold, moist, and incompletely mixed coal and pitch at the top and must be capable of delivering the mixture at the bottom in a condition suitable for briquetting. It will be abundantly clear that steam kneaders of this description should have a large capacity, a high internal temperature, and must be provided with stirrers which are only auxiliaries in the heating oven. This is particularly the case when a certain amount of drying has to be effected by the evaporation of part of the water content of the coal. Precautions must be taken to prevent partial condensation of the steam issuing from the jets, as this would increase the water content of the coal. The large steam kneaders working without heating ovens only find a use, therefore, where unwashed small coal containing little pit moisture is briquetted. For the object in view the limit is about 4 per cent. pit moisture.[2] But even if this is higher, good briquettes can be

[1] At the end of 1907, thirty-one factories worked with, and only seven without, heating ovens in Lower Rhenish Westphalia.

[2] Even then certain special briquetting methods or presses have to be applied.

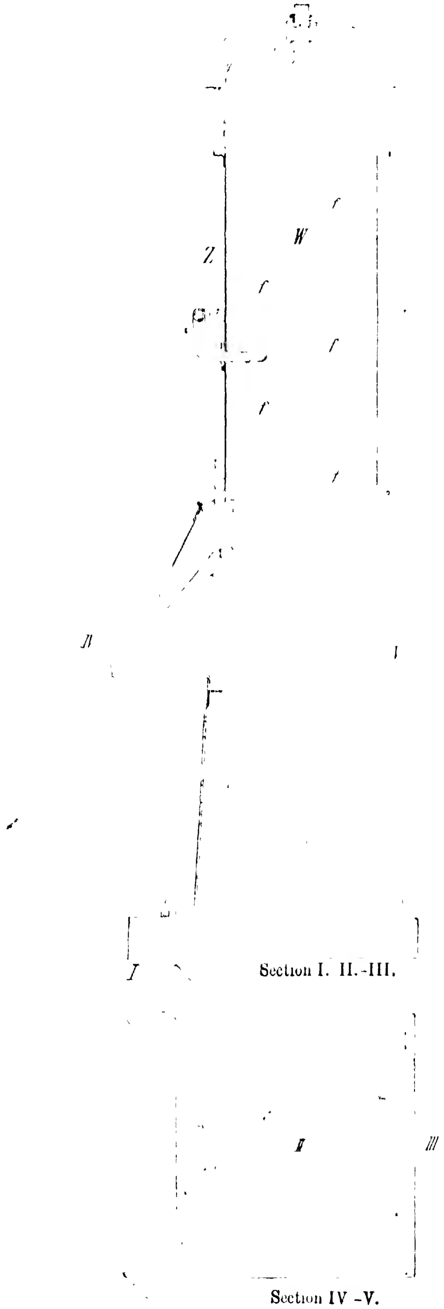


FIG. 40.—Steam kneader. Vertical section and horizontal section through the lower part.

FIG. 41 —Steam kneader. Side view. View from above and horizontal section through upper part.

prepared by adding a larger amount of pitch, which of course correspondingly increases the costs. With coal containing 6 per cent moisture the expenditure of pitch becomes so important that a special drying oven can scarcely be dispensed with to prevent uneconomical working or the preparation of inferior briquettes.

Measurements, Outputs, etc.—Large steam kneaders are constructed with a cylindrical working space up to 2 to 2·5 metres high and 1 to 1·2 metres diameter, for outputs up to 12 to 15 tons per hour. For two 3 kg. presses a *malaxeur* of 2 metres in height and 1 metre diameter of working space is amply sufficient. The stirrer shaft, with its twelve diametral alternating arms, makes 31 revolutions per minute. In the working chamber two to four jets open out with five openings of 20 mm. diameter.

The mixture, delivered cold from above, is thoroughly worked and subjected to the action of the steam issuing from the jets for 10 minutes, until it passes out at the bottom at a temperature of 80° to 90° C., which is necessary to make it plastic and adaptable to briquetting. For this purpose, as well as on the grounds given above, it is necessary that the temperature of the steam supplied should as a rule be between 300° and 350° C., but not above 400° to 450° C. A special superheater is therefore necessary in order to bring the steam from the boiler to this high temperature.

Steam Superheater (fig. 42).—In the briquette factories of Rhenish Westphalia and other districts the Schuchtermann & Kremer system of furnaces, built of refractory blocks, are generally employed. The furnaces are 5 metres in height, and inside, twenty-four cast-iron tubes *r* of 95 mm. diameter lie above and next to each other in four series 250 mm. apart. Below is a grate of 1·5 sq. metres surface. The tubes jut through the masonry of the furnace, are connected together by means of elbow-pieces, so that the boiler steam at 4, or at the most 6, atms. pressure and corresponding temperature (144° to 159° C.) led into the upper end of the leading tube must traverse the whole of the tubes of the series, in this way approaching nearer and nearer to the fire, becoming more and more superheated, until it is led to the steam stirrer from the lowest and hottest part of the furnace by means of a well-lagged delivery tube provided with a safety and escape valve. The pressure of the steam must not rise above 6 atms., otherwise the circulation tubes are likely to burst. To meet these conditions, therefore, care must be taken to instal corresponding reducing valves and safety appliances.

At the Zeche Blankenburg in Westphalia the Buttner design of superheater is used.[1] In the neighbourhood of the fire grate and the

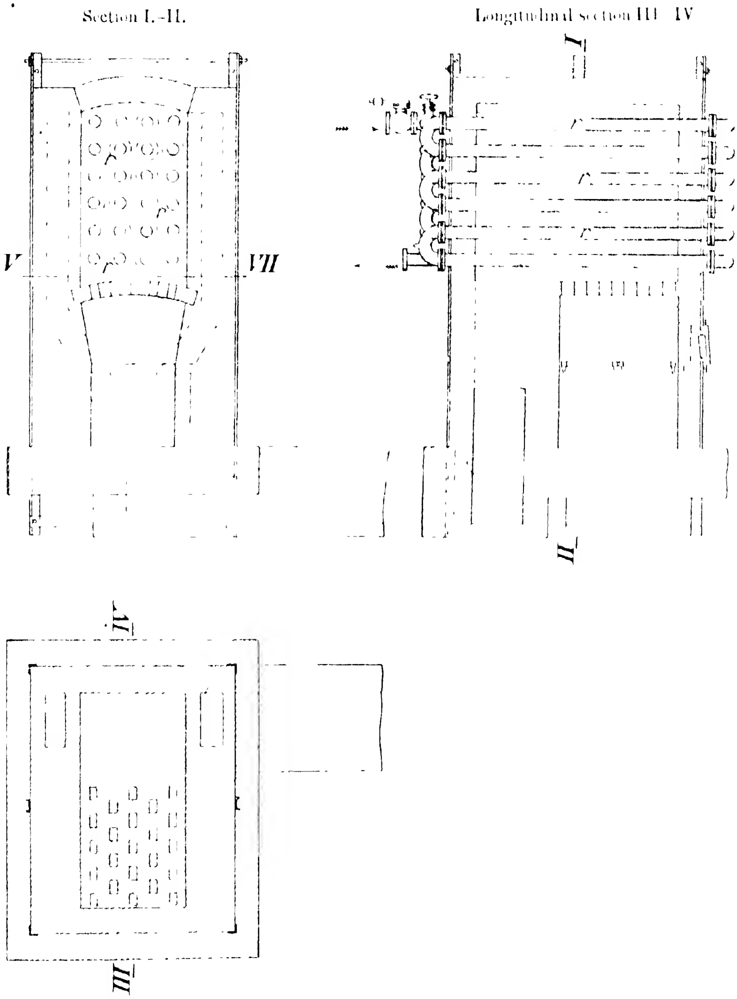


FIG. 42.—Steam superheater Scale 1 : 60.

crown of the furnace are situated single tubes 150 mm. diameter. These two tubes are connected with each other by thirteen spirally wound tubes of drawn sheet iron, each of about 19 metres length, 25 to 30 mm.

[1] *Niederrhein.-Westfal. Sammelwerke*, vol. IX., 1905, pp. 623–624, fig. 296, *a–c*.

diameter, and 3 mm. thickness of wall In contradistinction to the superheater described above, the whole of the individual tubes are situated in the free space of the grate masonry, so that none of the steam passing through them can give up any of its heat to the outside air. This superheater is distinguished by the slight necessity for repairs, high capacity, and low fuel requirements.

At many briquette factories in the kingdom of Saxony and elsewhere steam superheaters with vertical cast-iron tubes find application.

Briquette waste or coals of inferior value are used for firing superheaters. The quantity used for superheating steam from about 140 C. to 3000 C. amounts to 250 to 300 kg. per working hour, superheating to a higher degree requiring a correspondingly larger quantity.

As a rule the steam superheater is placed outside the briquette factory building, close to the press-room.

2. Small Steam Kneaders (without Superheater) (fig 13)—For the completion of the work of the heating and drying ovens, the kneader, fed with a good mixture of coal and pitch already heated to the extent of 90 to 95 per cent, requires considerably less working space, a much lower steam temperature, and shorter time to deliver prepared briquetting material

The working space alone requires a height of 1 5 metres, a diameter of 0·75 metre, and two jets, one of which is placed on the discharge opening side at a height of $\frac{1}{3}$ and the other on the opposite side at a height of $\frac{1}{4}$ of the height of the working chamber. A steam temperature of 165° C. is quite high enough If, as is very often the case at modern mining plants, steam at 7 to 8 atms pressure is available, no special superheater is required, because of the existing temperature of the steam (about 161° to 175° C.), which is quite suitable In such works, therefore, the steam superheater, which is costly in installation and working, has been quite given up, and only simple boiler steam is led to the kneader.

Steam Kneader for Coal and Liquid Pitch—At fat-coal collieries which are situated close to a coking plant with tar distillation and a briquette factory, the pitch obtained during the tar distillation (soft pitch) can be conveyed to the briquette factory in the liquid form through a main, and can there be added in the required quantity to the small coal, which has preferably been previously dried and heated, such, for example, is the method in vogue at the Zeche Holland III/IV, at Wattenscheid in Westphalia[1] and at the Rheinau briquette works.

[1] *Niederrhein.-Westfal. Sammelwerke*, vol. ix., 1905, p. 649.

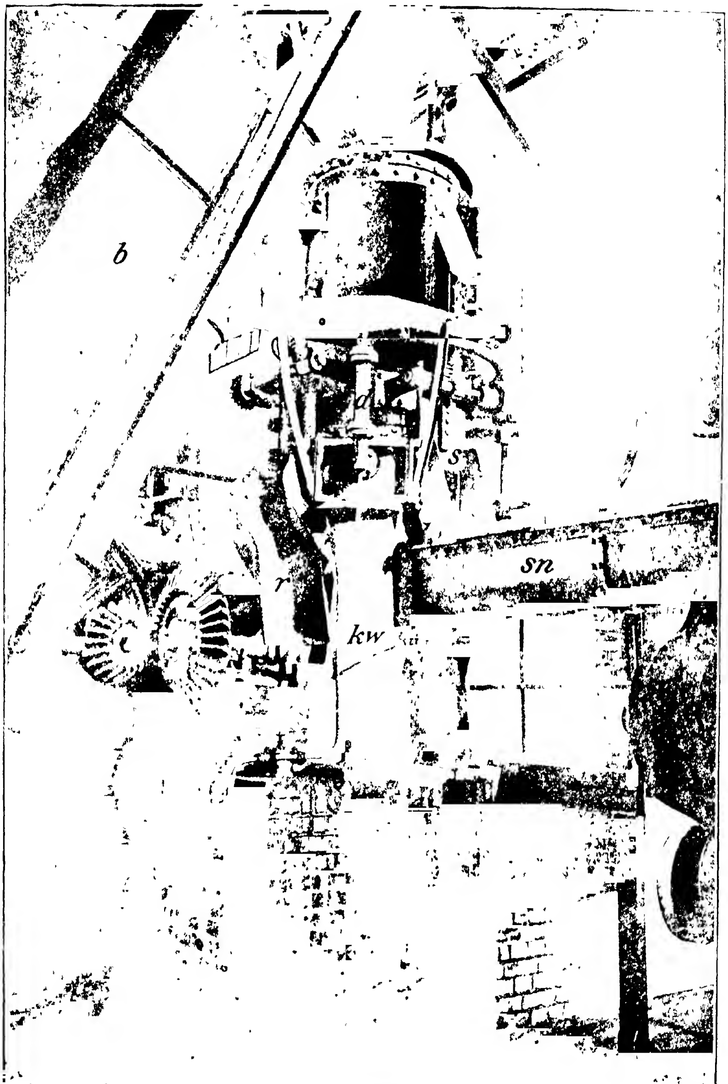


FIG. 13. Small steam kneader for coal and liquid soft pitch.

For the mixing of coal with liquid pitch, small steam stirrers with the usual arrangements have proved themselves to be equally suitable. As shown in fig 43, the mixture is conveyed by the conveyor *b* to the head of the kneader *kw*, whence it is carried through the opening of the slide *s*, while the jets of the steam pipe *d* blow steam at 200° C. into the pulpy mass. A worm conveyor *sw* carries the prepared mixture to a Tigler press (not shown). A slide *r* serves as an overflow for the removal of excess briquetting material supplied above.

II. Melting and Mixing Apparatus for Pitch and Tar.

According to W. Colquhoun,[1] a mixture of pitch and tar is used as a binding material at many works in Central France. Usually the amount of tar added is about 15 per cent. of the quantity of pitch, but at the La Chazotte works of the Paris-Lyons railway it amounts to 30 per cent. At the La Chazotte works the preparation of the liquid pitch and tar mixture is made in large wrought vessels 6 m. long, 1 m. broad, and 2 m. deep, which are slightly inclined towards the tapping hole and heated by means of coal fires.

A supply of 6½ to 7 tons pitch and 2 to 2½ tons tar can be liquefied in twelve hours with an expenditure of 300 kg. fuel.

At other works, such as the Rochebelle and Blanzy mines, a steam-heated cylinder with a revolving water-wheel shaft is used as the melting vessel. A direct pressure of steam is usually applied for any elevation of the liquid bond to a higher plane Mixing with the coal follows by means of a suitable revolving scoop wheel. After mixing, the briquetting mass must be obtained warm for steady delivery to the presses, as described above, which is again best effected by a steam stirrer.

III. Introduction of Naphthalene in the Steam Kneader by the Method of Jac. Busz and C. Fohr.[2]

This new method, which, so far as known, has only been applied experimentally as yet, consists in charging into the steam kneader moist washed coal mixed with some 3 per cent. hard pitch, and adding from an annular tubular spray 1 to 2 per cent. naphthalene[3] mixed

[1] Gluckauf, Essen, 1894, p. 1795.

[2] D R P, No 186,396, Class 10b, Group 7.

[3] Naphthalene, $C_{10}H_8$, which is obtained as a gas in the second fraction of coal-tar distillation, forms at the ordinary temperature yellow leaves if impure, colourless leaves when pure, which melt at 79° C.

with hot condenser water, and thoroughly kneading into the mixture by the aid of steam superheated to 300° C.

This not only causes a volatilisation of the naphthalene, which takes place at about 216° C., but also evaporates the excess of water from the small coal. But while the water vapour obtained in this way escapes from the top of the kneader, the naphthalene gas remains in the coal-pitch mixture, to which it clings very tenaciously, and condenses again in the cool lower portions of the kneader. The briquetting material thus obtained is compressed in the usual way.

The principal advantage of this method lies in the absence of special drying appliances (heating ovens, table or drum dryers, or the like) for the damp washed small coal, which effects considerable economies in space, installation, and working. However, the economy in binding material is not considerable. With regard to the technical and economical suitability of the method, further experiments, as well as the results of practical application on a working scale, are awaited. That strong briquettes of first quality will be obtained by it successfully seems at least doubtful. (See above, section on "Binding Materials.")

SECTION VII.

PRESSING.

A. GENERAL.

THE production of good coal briquettes demands, in the first place, suitable raw materials (coal and bond), which must possess certain properties, secondly, the preparation of a good briquetting mixture from these raw materials, and finally, a good compression of this mixture. None of these three principal requirements can be neglected. The suitable fulfilment of the first two has been the object of the sections already treated, and it now remains to consider the pressing which is effected by means of machine presses.

The task of the machine presses is to compress the thick pulpy plastic mixture delivered from the bottom of the steam kneader at 80° to 90° C. into blocks of certain uniform shape and size and of equal weight. It is additionally demanded that the blocks shall be as far as possible uniformly dense and strong, capable of being carried and stored, resisting weathering and so on. (These requirements are more accurately defined and thoroughly discussed in Section I., p. 4 *et seq.*)

In most of the machine presses the pressing operation is completed in iron or metal moulds of the section of the block to be prepared, but of considerably greater length or depth than would correspond to the thickness of the block. The mould is first filled loosely with the warm pulpy mass flowing in, after which follows the compression, which is either one sided, *i.e.* a pressure stamp is forced into the mould from one end, while the other end is kept closed by means of a plate or the previously completely pressed briquettes, or two-sided by means of two pressure stamps acting in opposite directions, one from each end of the mould.

In every case the walls of the mould and the stamp filling the section must prevent the squeezing out of the enclosed mass, only air and vapour must be allowed to escape during compression. The

plastic mass itself is, up to the end of the stroke of the stamp more and more compressed to a certain fraction of its original volume in this way producing a resistance which is made up of the friction of the particles of the mass against each other during their displacement and the friction of the walls of the mould and naturally increases as the compression increases. The finished briquette is finally pushed out of the mould. At first, still hot and containing the bond (pitch) in the soft condition in which it surrounds and cements the individual particles of coal, the briquette requires a certain amount of cooling in order to attain the necessary strength by the solidification of the pitch.

The briquettes must be as uniformly dense as possible throughout their whole mass in order to exhibit uniform strength. This is not attained, however, with briquettes prepared in certain old presses in which the pressure only acts on one side and never exceeds 100 kg. per sq. cm. Gérondeau[1] found that parallelepipedic pressed coals of 29 × 18.5 cm. = 536.5 sq. cm. surface by 11 cm. high, prepared with such presses by Dehaynin at Charleroi, showed a density of 1.21 at the top and 1.16 at the bottom while in the middle the density was still lower. This is shown diagrammatically in fig. 11, a representing the top and a' the bottom of the briquette.

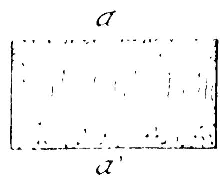


FIG. 11.—Vertical section of a briquette pressed from one side (the top).

Pressed coals from the Zeche Wiesche at Mulheim (Ruhr), which had a surface of 30 × 24 = 720 sq. cm. and a height of 11 cm., showed a density of 1.20 at the top and 1.19 at the bottom. The irregularity in the density therefore increases with the height of the briquettes. Gérondeau found, further, that of the pressure exerted in the pressing, 70 per cent. was consumed by friction on the walls of the mould, and that accordingly 30 per cent. at the most is really usefully employed. From this it follows that mass, surface, and height of the briquettes must bear a certain relation to each other in order that the force applied can be used to the best advantage.

A circular section would appear to be the most suitable from these considerations, if it did not possess the disadvantage that it gives rise to too many unnecessary interspaces during storing; a rectangular section with rounded corners or edges which is almost universally applied, seems to be the most desirable.

[1] *Revue universelle*, x. p. 112, and Gurlt, pp. 12–13.

Now, the smaller the surface of the section the less should be the thickness of the pressed coal a maxim which is almost usually followed in practice Disregard of this results in considerable loss of power by friction on the walls of the mould as well as irregularities in the density

The pressure applied during pressing, however, does not depend solely upon the shape and size or the surface section and thickness of the briquettes to be produced, but also upon the nature of the coal and the binding material, the content of water, proportions in the mixture, as well as its temperature and intimacy.

If, apart from the nature of the coal, these latter factors have been duly considered in the light of the principles laid down in the previous sections, then, according to experiments made at Blanzy,[1] the pressure per sq cm of surface must be taken to not below 100 kg = 100 atms for soft coal, not below 140 to 150 kg = 140 to 150 atms for hard and granular coals, to obtain the usual large shapes According to H. Fischer,[2] however, considerably higher pressures must be applied, namely:—

For soft coals at least 200 kg = 200 atms.
„ hard coals up to 300 kg = 300 „

These heavy demands are, as a matter of fact, fulfilled by all the best modern briquette presses, but not by many of the older press systems The Couffinhal press invariably works the softest Westphalian coal after passing through the heating oven at a normal pressure of 200 atms, which can be increased to 300 atms should necessity demand it In any case, a high pressure, up to a certain limit is of advantage, since the amount of binding material used can be diminished.

For small briquettes, however, considerably lower pressures can generally be applied, as a general rule, a pressure up to 50 kg per sq. cm is enough for the production of briquettes of sufficient strength.

If the briquetting coal is sent for pressing undried, with a high content of water, the disadvantage results, with practically all machine presses, that a lower pressure, only about 50 atms against 200 atms. can be applied, since the excess of water cannot escape from the mould,[3] and at the same time prevents the pressing together of the

[1] Gurlt, p 43

[2] H Fischer, "Mitteilungen aus der Weltaustellung," in Paris, 1878, Dingler, 232, vol 1879, p 97

[3] Only few systems (Steven, Révollier, Bourriez) are arranged for the working of moist material or for the draining away of water, as will be seen from their descriptions.

coal, etc. There results, even at moderate pressures, instead of a compact uniform block a briquette composed of a series of parallel layers of slight strength and resistance to weathering. This deficiency can only be provided for to any degree by considerably increasing the pitch addition up to 10 per cent instead of the 7 per cent otherwise added to dry coal, in which case the stratification disappears during the cooling of the pressed coals. In order to produce good briquettes filling all the necessary requirements for effective economical use, the briquette presses must generally fulfil the following conditions:—

(*a*) Uniform, automatic supply of the briquetting material and filling of the moulds.

(*b*) Uniform (two-sided), correspondingly high pressure and the attainment of a density of the highest possible uniformity.

(*c*) Mechanical discharge of the prepared briquettes without injury and without leaving any of the sticky briquette mass in the mould.

(*d*) Possibility of a large output with as little waste as possible.

(*e*) Simple compact, strong construction with security against vibration shock or breakages under extraordinary demands.

(*f*) Low wear and tear, ready accessibility, and easy renewal of the parts which are readily worn.

(*g*) Need little attention with a consequent small working staff, moderate requirement of power.

The critical examination of the various machine presses must be made principally with a view of determining whether and how far they correspond to the above mentioned conditions or not.

B. COAL-BRIQUETTE PRESSES.

There is a great number of designs of briquette presses which have mostly come into being in France, Belgium, England, Germany and North America; many of them have found application on a working scale, but a considerable portion must be considered as out of date at the present time. Briquette presses can be divided into three classes according to the nature of the pressing:—

I. Machines in which the pressure is applied to one side of the briquettes—presses by Mazeline, Steven, Crozet-Exter, Révollier, Dupuy, Détombay, Middleton-Détombay and many others.

II. Machines in which the pressure is applied to two sides (double) —*e.g.* Biétrix, Couffinhal, Veillon, the revolver presses of Middleton,

Yeadon, Yeadon-Busse, etc., and the toggle-joint presses of Tigler, Schuring, and others.

III. Machines with a tangential action subdivided into:—

(1) Presses in which one briquette is formed against the back of another: rope and sausage presses of Evrard, Bourriez.

(2) Presses in which the pressure is produced by means of a pair of rolls: roll presses of Loisseau, Gilly, Mason de Beer, Zimmermann, Fouquemberg, Bilan Mashek, and others.

The development of the briquette industry in Europe has largely been in favour of the double-pressing machines (Class II.), since with them denser, stronger, and more uniform briquettes can be produced than with machine presses of the other classes, as well as in the most desirable prismatic forms of various sizes. In North America, however, where small egg-, ball-, or disc-shaped briquettes have been preferred of late, the roll presses of Belgian or American design find most use.

Class I. Machines with One-sided Pressure.

Of the numerous various types of presses of this class which were introduced into France, Belgium, and England in the fiftieth and eightieth years of the nineteenth century, only a very limited number are to be found in use at the present time, mostly at the oldest works in those countries. It has already been shown above that machines compressing from one side only can fulfil the requirements for the production of briquettes as strong and as uniformly dense as possible only to a somewhat limited extent (see p. 113). As well known examples of this class it will only be necessary to briefly describe the following machines:—

Presses by Mazeline & Co. (fig. 45).[1] The Mazeline press is a steam press in which the pressure is applied directly in an upward direction. It works with pressure stamps and closed moulds. Ten rectangular moulds lined with sheet steel or bronze are placed in the revolving table E, which is built after the style of the revolving Middleton mould table (see p. 118 *et seq.*). The mixture of small coal and pitch is thoroughly incorporated and heated in the steam kneader (*malaxeur*) B by stream of superheated steam, and the plastic mass falls into the trough J, from which the moulds K are filled by means of the revolving arms of the distributor D. The upper surface of a prismatic

[1] E. Bornstein in Dammer's *Handbuch der chemischen Technologie*, vol. iv., 1898, p. 80, figs. 39 and 40.

press stamp projects into and forms the bottom of each mould. When the mould filled with the mass arrives over the beam F revolving about the fixed point n, the revolving table E halts in its rotatory motion, steam is admitted below the piston D, the ascent of which, through the intermediary of the piston rod M and the beam, forces the press stamp T into the mould and the mass is compressed against the strong fixed plate L. The volume of the mass is diminished by an amount proportional to the stroke of the press stamp. The beam F is provided with swing o, which has a curved head by means of which the pressure against the stamp is always axial during the ascent of the beam.

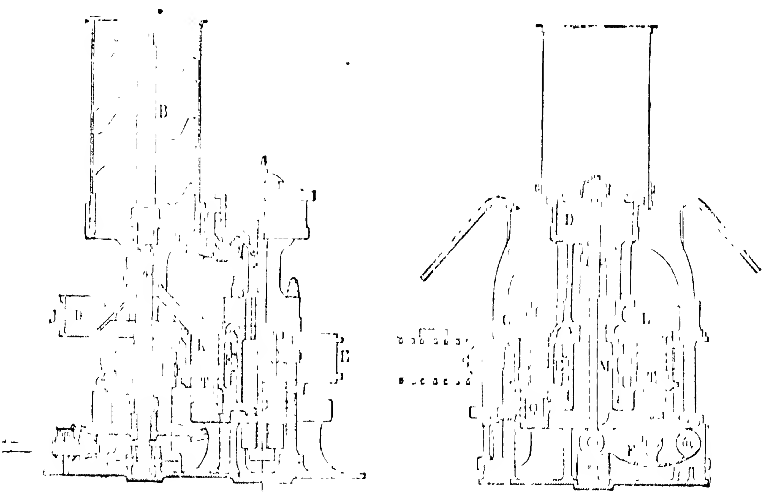


FIG. 45.—Briquette press by Mazeline & Co.

The ten press stamps rest on an inclined plane Q, the stamps are moved along this plane as a result of the rotation of the disc E after each pressing, become more and more elevated, until finally they fill the whole mould and in this way the briquettes are forced out one after another. When this happens the briquettes are picked up by a movable shovel lifted on to a moving band conveyor, which leads to the railway waggon or the store.

The return motion of the revolving disc is effected by means of a catch which sets a set of wheels in motion. The Mazeline press is made in four sizes; the largest produces twenty 11 kg briquettes per minute, which is about 13 tons per hour or 130 tons per day of ten hours. It consumes 20 H.P. and costs about 24000 marks.

The Steven Press.—This press, made by Henri Steven in Charleroi,

is very similar to the Mazeline press in principle, but is of greater simplicity. The principal difference is in the absence of hydraulics. The piston rod of a simple-acting, vertical steam cylinder is directly connected to a one-armed lever which presses the stamp into the mould when the piston rises. Two briquettes are prepared at every stroke; by $2\frac{1}{2}$ revolutions of the mould table per minute fifty blocks of 7 kg. weight are obtained equal to 21 tons per hour, or 210 tons per day of ten hours.

Recently the firm has introduced the following patented improvement. On the return of the piston, which takes place by its own weight, a steam cushion is produced between the piston and cylinder cover by means of a recoil valve in the piston which closes the steam exit before the end of the stroke of the piston. This arrangement has proved of special service in presses of this description, since shocks set up in consequence of the removal of the resistance are quite prevented by this means

In the latest practice these presses should permit of the production of briquettes from coals of high-water content (about 15 to 16 per cent) without previous drying In more recent times, since the firm of Schuchtermann & Kremer in Dortmund have acquired the patent, thorough experiments have been made after certain alterations in construction to obtain useful briquettes directly, but in the autumn of 1908 the tests were not concluded. The freshly prepared briquettes contained 7 to 8 per cent. less water than the coal used, and after short storage, dried so much further by evaporation that the residual water did not amount to much more than in the pressing of dried coals Complete success of the experiments would allow considerable simplification of the briquetting of wet coals by the abolition of the drying appliances and their attendance.

The Middleton-Détombay Press (figs 46 and 47).[1] The press constructed by the Englishman Middleton in the year 1845 was the first to possess a revolving table. Later it was considerably improved by Détombay, and has been manufactured by the firm August Détombay at Charleroi in Belgium as the Middleton-Détombay press, and has in due time found a further field on account of its relatively simple lasting construction and its large capacity. It is a steam machine with an indirect compression in an upward vertical direction As will be seen from the diagram, this is effected by a bent lever F F′, which is alternately

[1] E. Bornstein in Dammer's *Handbuch der chemischen Technologie*, vol. iv., 1898, pp. 81-82, figs 41-42.

stretched out vertically and bent to an obtuse angle by means of the pulley B, the crank shaft W, and the connecting rod E. In this way the vertical press stamp K fastened to the lower arm F of the lever is always being pressed into or lifted from the mould filled with the briquetting mass and closed at the bottom by a fixed plate. A heavy weight J, consisting of an iron box filled with stones, bears on the bent

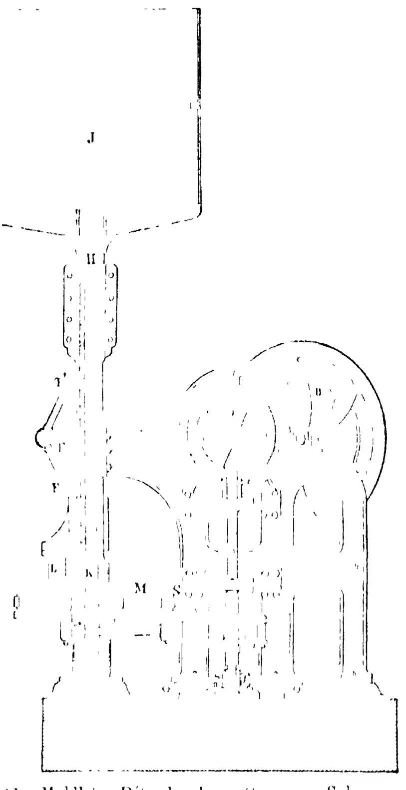


FIG. 46.—Middleton-Détombay briquette press. Side view.

lever. This weight has to perform the real pressing, and can be increased or diminished according to requirements The next movement of the mould table M brings the finished briquette under the pusher L, which is fastened to the pressing stamp K, moves with it, and on the downward stroke pushes the briquette out of the mould, which has moved away from the fixed plate, into the hand of a workman, or on to a band conveyor

The intermittent revolution of the mould table M is effected by the

bevel wheels R driving a vertical shaft with the connecting rod N, the cross lever and the pawl X held in position by a spring, the pawl engaging in corresponding notches in the circumference of the revolving table.

The magnitude of the pressure exerted averaged, according to Colquhoun,[1] for four cases observed in Germany 101 atms., but for two presses observed by Tittler[2] at Funfkirchen in Hungary only 55 atms. The hourly output of the presses is 4½ to 5 tons briquettes, each of about 6.5 kg. weight, and 6.8 to 7 tons at Funfkirchen.

The cost of production amounted to 7.30 marks at a Belgian works and 5 marks per ton at Funfkirchen.

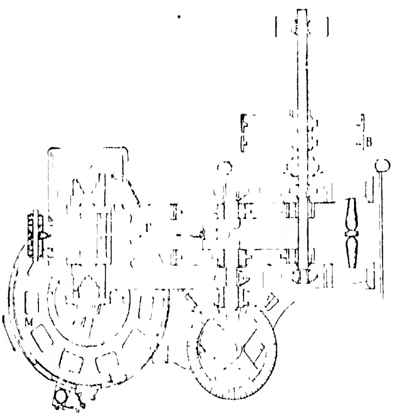


FIG. 47.—Middleton-Détombay press. Plan.

Weight and Price.—A press and accessories weighs about 30 tons and costs about 19,600 marks.

The press was formerly used here and there in Germany, but has now been largely replaced by the Couffinhal press. It still finds use in foreign countries, *e.g.* at Hong-Kong, in Eastern Asia, and so on.

The Révollier Press.—This press, introduced by Révollier & Co. of St. Etienne in 1861, is a machine in which the pressure is hydraulic and exerted in a vertical direction, and is specially noteworthy because it permits of the direct working of wet coal and is equipped for the necessary removal of the excess water. At the St. Vast shaft of the Anzin pit it consists of a revolving tray table provided with four groups of 21 moulds. One of these groups is filled with the moist mass conveyed from the kneader (*malaxeur*) by means of a worm conveyor, the table makes a quarter of a revolution, and the group concerned is brought under a solidly fixed iron block, when 21 press stamps are forced upwards into the mould by means of a common plunger operated by hydraulic pressure.

The pressure, gradually increased to 150 kg. per sq. cm., allows the greater part of the water content of the coal to flow away, the drainage being completed after the next quarter revolution of the

[1] Gluckauf, Essen, 1894, p. 1796. [2] *Berg- und Huttenm. Z.*, 1901, No. 52.

table. Then the finished briquettes are pushed out of the moulds by twenty-one small hydraulic stamps and passed on to the band conveyor by an attendant. After a further quarter revolution the filling of the moulds begins afresh.[1] The output of the press per hour is about 12 tons, so that per day of 22 working hours, each of the two presses yields about 260 tons, or a total of 520 tons of cold-dried briquettes, each about 8·7 kg. weight. At the No. 2 briquette factory of the Blanzy coal pit[2] the pressing was commenced by a large pump exerting a pressure of 45 kg per sq. cm. and finished with small high-pressure pumps at 400 kg. per sq. cm. A total force of 540 tons acted on the hydraulic pistons, 42 cm. diameter, so that a pressure of 100 to 110 kg was exerted on the briquette. Regulation of the pressure was effected in advance by means of a safety-valve, and the total time of pressing amounted to 30 to 35 secs

The water content of the briquetting mixture, which was composed of washed coal containing 14 to 15 per cent moisture and about 9 per cent. pitch, amounted to 16 to 18 per cent after the injection of superheated steam into the kneader (of 2·6 m. height and 95 cm diameter) After the final pressing only 3 to 4 per cent. moisture was left in the briquettes, so that about 80 per cent of the water content of the mixture had been squeezed out In this case the removal of the briquettes by means of a stamp was effected by lowering the moulds. A mechanical rake delivered thirty briquettes at a time on to a truck, which took them to a distant store.

The Dupuy Press[3]—This press is a small steam press working horizontally, made by Dupuy et Fils of Paris, in which the briquettes are produced altogether in a tray mould by means of press stamps. It delivers only ten to twelve briquettes of 4 to 5 kg weight per minute (equal to 24 to 30 tons per 10 hours), requires 7 H P, and costs about 7600 marks. A Dupuy press at Sables d'Olonne prepares 24 tons daily at an expenditure of 3·5 marks per ton, which, apart from the cost of the briquette coal, includes the total expenditure on attention, maintenance, use of material, and interest.

Class II. Machines with Double-sided Pressing.

This class includes, as already stated, the most widely used press systems of the present day. Their introduction began towards the

[1] According to Salomon in *Z f B.-, H.- u. S.- W*, xxxv, 1887, p. 328.
[2] According to Dupont de Dinechin, Gluckauf, Essen, 1894, pp 617–618.
[3] Gluckauf, Essen, 1894, p. 1796

end of the 'seventies and the beginning of the 'eighties in the last century. Since that time the numerous machine presses of Classes I. and III. have been more and more replaced.

The pressing is effected by two pressure stamps moving uniformly in opposite directions, either vertically or horizontally, nearly or quite simultaneously. Compared with machines of the other classes, the stroke of the stamps is shortened considerably, the friction of the coal-pitch mixture on the walls of the mould is appreciably diminished, and with the same absorption of power a much greater density and uniformity of the briquettes is obtained. With the best machines of this class many other advantages are added to these, such as larger outputs, lower costs for attendance and maintenance, and so on.

The Couffinhal Press (figs. 48–55). This press, introduced about thirty years ago, was first constructed by G. J. P. Couffinhal, who was at that time manager of the Forges et Ateliers de la Chaléassière of Biétrix et Cie at St. Etienne, is by far the most used of the press systems up to the present, above all in Germany, because of its constructional advantages and its irreproachable performance, especially since the firm of Schuchtermann & Kremer of Dortmund, who took up the patent of Biétrix et Cie in due course, improved the system in many ways, and since 1881 have built most of the machines of this class.

From 1881 to the end of 1907 Schuchtermann & Kremer have delivered altogether 230 Couffinhal presses, of which 211 have been for Germany alone (principally for Lower Rhenish Westphalia, and further for briquette factories at Emden, Aachen, Saarbrücken, Upper Rhine, Oberkirchen, Berlin, Stettin, Upper Silesia, and so on), the remaining deliveries of presses being distributed between Austria, Hungary, Turkey, Roumania, Russia, Sweden, Holland and colonies (Sumatra), Belgium, Portugal, United States, China, and Japan.

The following is a summary of presses delivered:—

198	were for the production of	3-kg. briquettes.	
17	„ „ „ „	5 „ „	(1 press for ore)
6	„ „ „ „	9 to 10 „ „	
4	„ „ „ „	6 and 1 „ „	(1 press for ore)
and 1	„ „ „ „	7 „ „	

Recently the construction of Couffinhal presses in Germany has been taken up by the Maschinenfabrik Baum in Herne, the Maschinenbauanstalt Humboldt in Kalk, etc. First the nature of the Couffinhal press will be dealt with briefly.

As will be seen from figs. 48 to 51, the spur wheels r r_1 are re-

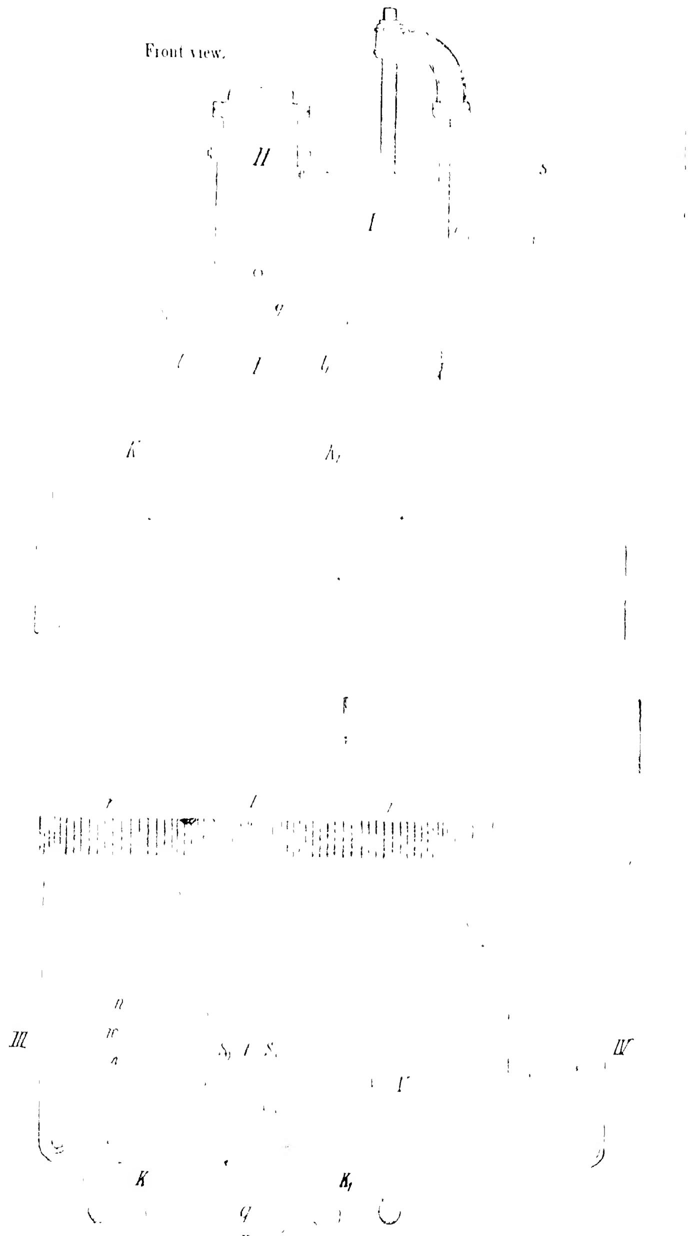


FIG. 45.—Continual briquette press. Front view and plan. Scale = 1 : 30

volved in opposite directions by means of a tooth drive (recently with double helical teeth). To their shafts the disc cranks K K_1, provided with steel pins, are keyed These cranks are connected by link bars l l_1 to a cross-head q, which communicates its motion to a peculiar system of levers consisting of an upper and lower double swinging beam So and Su and the tension shears Z connecting the two pairs of levers. The fixed fulcrum of this system of levers lies in the lower double swinging lever and the base of the frame at d. Both double beams carry one press stamp p_o or p_u, in addition to which the upper

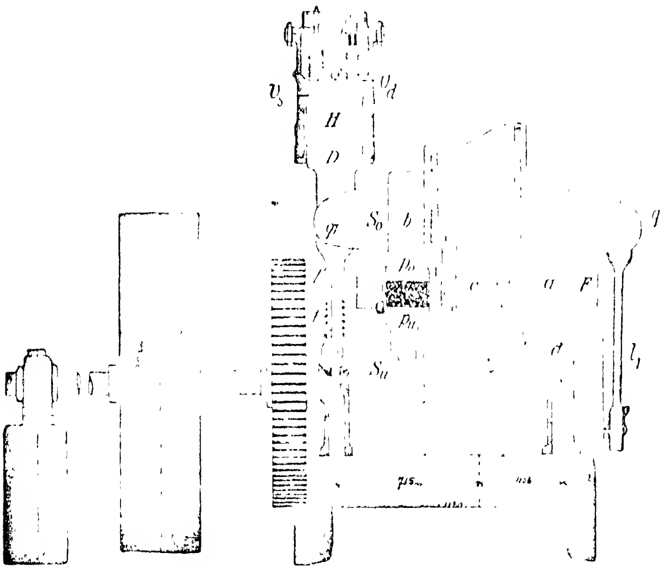


FIG 49 – Couffinhal press. Section I.–II.

beams carry the diametrically opposite stamp a for pushing out the briquettes. The stamps are guided vertically in the fixed centre-piece c (fig. 51).

The disc-shaped mould table F is situated between the pairs of swinging beams; during rotation it glides on a fixed foundation plate u, which forms the bottom of the radially arranged moulds, except where the action of the stamps occurs. On revolving the table the moulds are filled one after the other with the plastic briquetting mixture by means of the distributor V, after which they are brought between the press stamps.

During the commencement of compression, which is at first only

exercised by the upper stamp p_o (fig. 49), the pressure surface of the lower stamp p_u lies in the plane of the foundation plate u. As soon as the briquetting mass offers a certain resistance to further compression, the point of revolution of the upper swinging beam is moved from the cross-head q_1 to the pivot b, which carries the beam, the head of this beam lifts, and, with the help of the hydraulic cylinder H and the tension shears Z, raises the lower beam with its stamp p_u, so that the briquette is now compressed from below. Further revolution of the disc cranks K K_1 acts in such a way that both stamps are drawn

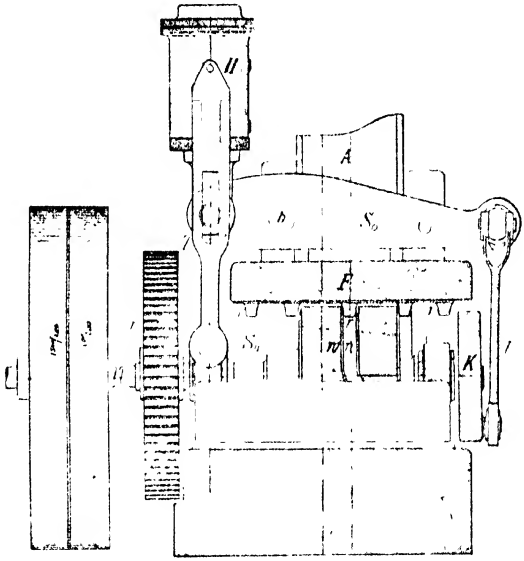


FIG. 50.—Couffinhal press Side view. Scale = 1 : 50.

out of the mould again, and the table turned by means of the guiding roll w_1 Then follows the compression of the next briquette in the neighbouring mould, and so on.

For a time the finished briquettes remain in their moulds until, after half a revolution of the table, they arrive successively below the discharging stamp a, which pushes them out below, where they are caught by a flap and caused to glide down a chute on to a band conveyor (fig. 55).

The hydraulic arrangement H, which has been mentioned, permits of the regulation of the pressure, hinders the overstepping of the maximum pressure, and provides the necessary provision against

breakages The individual portions of the Couffinhal press will now be considered at somewhat greater length.

The Distributor V (figs 48 and 51) has for its object the distribution of the mixture, conveyed from the kneader by a short worm conveyor s to the moulds Consisting of a cast-iron cylinder open at the top, of about 900 mm. internal diameter and 280 mm height it is arranged immediately above the round mould table so that it overlaps about one quarter of the upper surface containing three moulds The cast-iron bottom is cut away accordingly In the centre of the cylinder there revolves a vertical shaft carrying two radial, wrought-iron wings slightly bent and fixed opposite to each other. These move over the bottom of the cylinder, pick up the mixture, lead it to the slit, and scrape it into the moulds which are immediately below, until they are filled.

The shaft of the distributor is usually extended upwards to the head of the steam kneader and driven from the stirring shaft by means of gear-wheels (fig 55).

In briquette factories where two neighbouring presses are supplied from a large steam kneader with two delivery openings below by the aid of two short worm conveyors, the distributor shafts are driven from the horizontal shaft of the conveyors by means of bevel wheels

The Mould Plate F is, in most of the 3-kg briquette presses, a wide, annular, cast-iron disc of 1100 to 1200 mm diameter, in whose inner portion, the mould rim 160 mm wide, ten (seldom twelve) rectangular mould openings with rounded corners are cut radially The real moulds, in the shape of renewable boxes of a soft metal are pressed into the holes by hydraulic pressure after carefully smoothing the walls of the latter. Formerly phosphor bronze was used for the boxes but recently delta metal—an alloy of copper, zinc, iron, and tin with an addition of phosphor copper—has shown advantages on account of its considerably higher tensile strength and toughness. The following table gives information as regards the tensile strength and ductility of delta metal and phosphor bronze :—[1]

	Cast Delta Metal.	Delta Metal rolled at a Red Heat.	Cast Phosphor Bronze.
Tensile strength, kg. sq. mm	32 38	50 (av.)	29
Elongation, per cent.	10-19	13	17 5

[1] According to Dammer's *Handbuch der chemischen Technologie*, vol. ii. p. 721.

Longitudinal section III - IV.

Horizontal section V.-VI

FIG. 51.—Couffinhal Press. Longitudinal and horizontal sections. Scale = 1 : 30.

As a result of the great amount of friction arising during the pressing, cast iron and even hard steel wear away too rapidly. Fig. 52 shows under I. the section of a new mould (the uniform, if only slight, widening towards the bottom facilitates the removal of the prepared briquette), under *Ia.* a partly worn out, and under *Ib.* a mould of phosphor bronze which has become quite unusable. At the cylindrical circumference of the mould table holes are cut at definite distances, from which inclined lubrication tubes lead inwards to the fixed cast-iron foundation plate *u*, on which the mould plate glides during its rotation so that the whole must be well oiled. Below and near to the edge of the mould table conical metal leading or driving rollers *r* (figs. 50, 51, and 55) are placed.

Their number corresponds to the number of the moulds and their object is to rotate the mould table with the aid of the leading roll *w*,

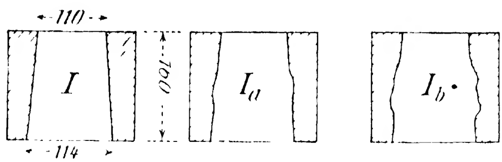


FIG. 52.—Mould linings (section) of a Couffinhal press showing the effect of use.

I. New mould. *Ia.* Mould after some use. *Ib.* Unusable mould, completely worn out.

after the pressing of each briquette; *i.e.* to rotate the table round the central bearing *e* until the next mould filled with the briquetting mass occupies the position of the preceding one between the upper and lower press stamps. In the older presses the rolls are made of phosphor bronze, but in the newer ones they are made of delta metal. They are carried by steel bolts passing through holes bored vertically through the outer ring of the mould table and held fast by countersunk screw heads. The rolls require well lubricating; if they cease to revolve because of insufficient attention, rapid wearing out takes place owing to the powerful action of the guide rolls (see below).

Mould tables with exchangeable metal mould rims have recently been introduced with excellent results by Schuchtermann & Kremer for 6-kg. presses with the important object of making the press applicable to the production of 3-kg. briquettes, in cases when the demand for large briquettes fails temporarily. Such a mould table is built up of two special concentric parts, the outer ring of cast iron, with twelve steel bolts and driving rollers into which an easily removable

mould rim of phosphor bronze or delta metal is inserted. The latter can carry either twelve large moulds for 6-kg briquettes, or twelve

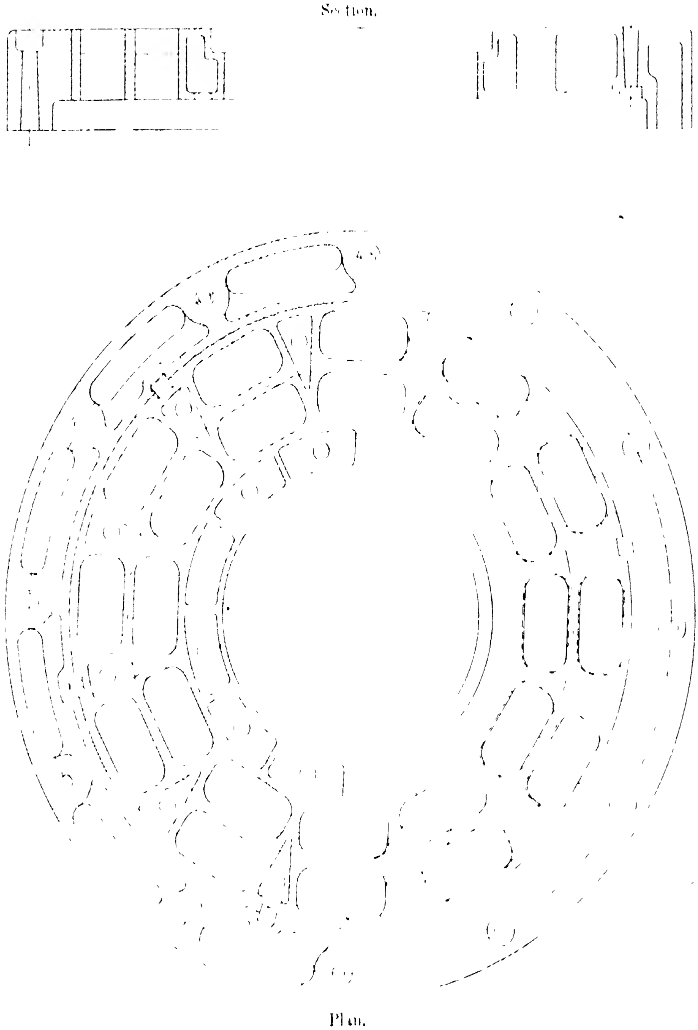


Fig. 53. Mould plate with double moulds for a Couffinhal press.

double moulds or twenty-four moulds of half size for 3-kg briquettes. According to the size of briquettes to be prepared, one mould rim is previously exchanged for the other.

Fig. 53 shows in section and plan a mould table with twelve sections

containing double moulds for 3-kg briquettes It differs from a mould table for 6 kg briquettes principally in that the large almost square moulds are divided longitudinally by means of a metal bridge into two moulds of the size of 3-kg briquettes These moulds are arranged tangentially, while those of the usual 3-kg presses lie radially The moulds of the metal mould rings need not be fitted with linings, they are only carefully smoothed out By means of corresponding double stamps the crown plates permit of the simultaneous pressing and removal of two briquettes, consequently, presses equipped in this way are also called double presses.

The outside diameter of the mould plate of a 6-kg or double press is 1700 mm, the exterior and inner diameter of the metal mould crown are 1380 and 625 mm. respectively, its thickness, as in the 3 kg. presses, is 160 mm.

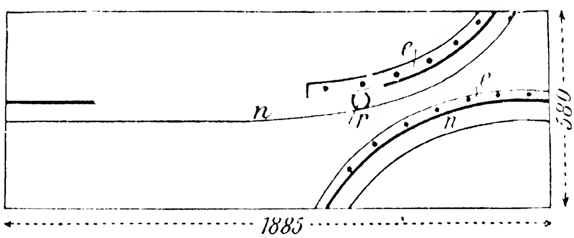


FIG. 54 —Development of the leading rolls of the Couffinhal press.

The rotation of the mould table is effected by the leading roll in conjunction with the driving rollers previously described For a 3-kg press its diameter is 600 mm, width 540 mm., and it is made of cast iron 30 mm. thick It is keyed on the shaft of the crank disc K (figs 48 and 51), and carries on its circumference a deep trapezium shaped groove n, of section adapted to the width of the turning roller r Fig 54 shows the surface of the roll rolled out into a plane. As will be readily seen, the groove runs spirally at the commencement E, and then —for nearly two-thirds of the circumference—it runs straight and at right angles to the axis of rotation, when it again takes a spiral form until it leaves the roll.[1] By the continual rotation of the roll (in the direction of the arrow, fig. 48) all the driving rollers of the mould table engage with the beginning of the groove and are compelled to follow its course to the end. In this way the spiral path of the groove produces a displacement of the roller sideways and a consequent

[1] This part of the groove appears as a special groove in the diagram, fig. 54, but really only forms a continuation of the straight part of the groove.

revolution of the table the straight portion of the groove holding the table fast during the pressing of a new briquette. During the turning period the pins of the crank disc describe an angle of 105°, and an angle of 225° during the period of pressing.

The parts of the groove subjected to the most stress are the left-hand surfaces of the curves at the beginning and the end. These pressure surfaces are protected therefore by a layer of steel 12 to 15 mm. wide, and screwed into a corresponding hollowed out portion of the groove. As a rule they only require renewal at the end of a year.

In any case, the whole of the turning mechanism needs regular control, and must be kept in the best condition. It is clear that even a slight amount of play between the leading rollers and the groove must result in the press stamp and mould not acting sufficiently in unison, thus easily giving rise to heavy damage, breakages, and so on.

The Press Appliance with Hydraulic Adjustment. In the original design steel cranks were keyed on to the main shafts driven by the pair of spur-wheels r r_1 for moving the link bars. Nowadays suitable cast iron crank discs, 580 mm. diameter and 110 mm. thick, with steel pins acting like fly-wheels, are used in their places. The disc cranks revolve in opposite directions like the pair of rolls of a roll crusher. The crank thrust exerted on the upper double swinging beam by the link bars l l_1 amounts to 130 mm.

The spur-wheel with double helical teeth,[1] the driving shaft, the upper and lower swinging beams, and the cross heads are made of steel, while the tension shaft and the link rods are of wrought iron. The stamps carried from the swinging beams by the steel bolts b are made of cast iron; nowadays a light renewable end-plate of delta metal is screwed to the lower surface of the upper press stamp p. The surface of the plate is provided with a number of ribs corresponding to grooves to be stamped in the briquettes, as well as a raised trade-mark (usually the initial letter of the name of the mining company).

In the double presses mentioned on a previous page, provided with two series of moulds, two upper and two lower stamps are provided on common shafts for the simultaneous pressing of two briquettes.

For a sure operation of pressing free from shock, the press spring f on the one hand and the hydraulic regulator H on the other are of special importance. The steel press spring f (fig. 49) rests on the lower cross-

[1] Figs. 48 to 51 show ordinary toothed wheels only on account of simplicity of representation.

head of the lower swinging beam between the legs of the tension shears Z, and is fastened to the base of the frame by means of a cramping screw. It is so strongly compressed by the upper screw nut that it steadily

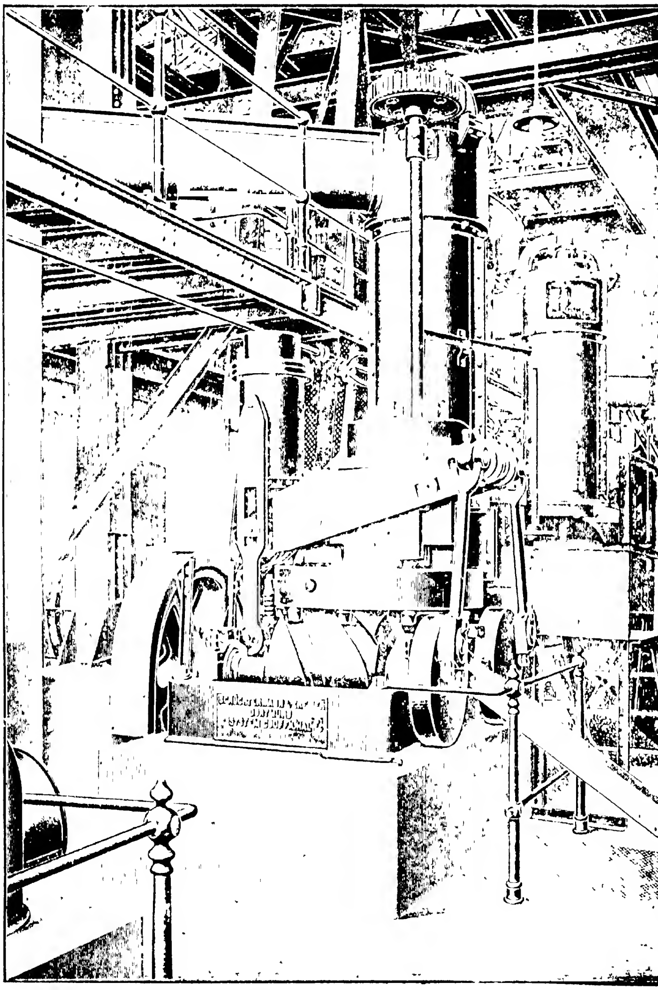


Fig. 55.—Continual press with steam kneader by Schuchtermann & Kremer.

exerts a definite downward pressure, amounting as a rule to 120 to 130 atms., on the cross-head, and thereby the tension shears and the lower press stamp p_u.

The tension shears Z carry, rigidly connected above, the cylinder of the hydraulic adjuster H, whose object has already been given

above on p. 131. Its internal arrangements will readily be seen from the section, fig. 49. The cast iron cylinder is divided into an upper and lower space by a strong interplate. The lower space is lined with red brass, and the pressure piston D, which is rigidly attached to the cross-head *g* of the upper double beam, enters it from below, being made tight by a circular leather washer. The diameter of the piston is about 220 mm., and the pins on each side of the cross head can be displaced vertically in slots in the tension legs, side displacement being prevented by nuts screwed on to the pins.

Above the pressure piston D the lower space of the cylinder is filled with water. The space is connected with the upper space by two cylindrical holes lined with red brass. Both openings can be closed by disc valves of red brass, which are fastened to vertical bars passing through the cover of the upper space. The suction valve *v* is pressed gently against the lower conical edge of the left hole by means of a lightly compressed spring, while the pressure valve v_1 rests on the upper edge of the right opening and is held down by a powerful spring. The tension of the springs can be regulated according to requirements by the aid of nuts, while the magnitude of the tension of the pressure spring determines the pressure of the compression. The upper cylinder space is barely half filled with water, the remainder being air. When the piston is driven upwards into the cylinder, the suction valve *v* remains closed under all conditions, and the pressure valve v_1 until the pressure of the water above the piston reaches the tension of the pressure-valve spring. As soon as this pressure is exceeded the pressure valve lifts and water streams upwards until the moment when the hydraulic pressure falls so much that the tension of the spring exceeds it. Then the pressure valve closes again. When the piston recedes the pressure valve remains closed under all conditions, while the suction valve opens as soon as a vacuum begins to form in the cylinder space and the pressure of the water in the upper space exceeds the low tension of the suction valve spring. Then the water flows from above until the suction valve is again closed on the return of the piston. A manometer attached to the cylinder shows the pressure existing above the piston D at any time.

The Operation of Pressing.—As soon as the mould table is turned and held fast by means of the leading roll, the descending pins of the disc cranks K K_1 (fig. 48) take down with them the link bars $l\,l_1$ and the upper swinging beam, whose point of revolution still lies in the cross-

head q_1 (fig. 49) between the tension legs, and is held down by the weight of the piston D and the water standing above it, the upper press stamp enters the mould (figs. 49 and 55) and presses the mixture resting on the lower stamp forming the base of the mould until the upper layer of the briquette produces such a powerful friction with the walls of the mould that it ceases to yield to any further compression. At this moment the fulcrum of the upper beam, which is pulled still further down by the link bars, is displaced from q_1 to b, the point of support for the upper press stamp, the beam now acting as a two-armed lever. The cross-head q_1 and the pressure piston rise and, since the water on the piston cannot escape upwards at such a pressure, lift up the whole hydraulic cylinder with the tension legs, lower swinging beam, and the lower press stamp, whereby the opposing press spring f is depressed accordingly. The briquette is now pressed from below by the lower press stamps to the same degree as it was formerly pressed from above

Immediately afterwards the crank discs rotate further the whole lever system with the hydraulic adjuster returns to the position it occupied before the compression, when the upper stamp is lifted out of the mould and the lower stamp withdrawn from below by the expansion of the press spring

In cases when for any cause—$e.g.$ as a result of the presence of foreign bodies such as pyrites, wood, or pieces of iron escaping notice—the mixture cannot be compressed to a definite degree, breakages of the parts communicating the pressure can easily arise. This danger is effectively obviated by the hydraulic safety appliance.

When the pressure exerted by the water in the lower part of the cylinder on the piston D exceeds 150 atms, the pressure valve v_a opens, since its spring cannot resist a higher pressure, and the piston D, with the upper swinging beam with its press stamp p_o can lift as much as the pins of the cross-head q_1 have play in the slots of the tension legs, without allowing the elevation of the cylinder, tension legs, and the lower swinging beam with its press stamp. Breakages therefore can scarcely ever take place.

The Ejecting Appliance.—A stripping stamp a (fig. 49) is fastened by means of a bolt to the upper swinging beam diametrically opposite to the upper press stamp, so that it can turn, and, like the upper press stamp, can slide vertically up and down the central bearing f (figs. 48 and 55) on its rectangular shaft. It is made wholly of cast iron, and its lower surface is smooth. During the revolution of the

table it is elevated, but during the pressing period it dips into the mould, immediately below, containing a finished briquette, overcomes the friction of the latter with the walls of the mould, and forces it downwards until it falls out. Immediately afterwards the stamp is lifted, the plate revolves, and brings the next briquette under the stamp ready for another cycle of operations.

The briquette pushed out falls first on to a flap placed immediately below the mould table and above the lower swinging beam. This protects the still hot and not completely solid briquette from fracture, is in stable equilibrium, and rests with its lower end on an inclined chute fixed close to it. Under the kinetic energy of the briquette falling upon it the flap first sinks, then rises again to its original position. The briquette now slides on to the chute (fig. 55) from this on to the band conveyor, which conveys it to the railway waggon.

The following table gives information on the maximum output of a simple 3-kg press and a double or 6-kg. press.

Kind of Press	No. of Moulds in Mould Table	Max Revs of Mould Table per min.	Time of Pressing, including Revolution	Max No of Stamp Strokes per min	Max No. of Briquettes prepared per hour	Max Output per 10 hours
			secs			tons
Simple 3-kg press	10	3·65	1·65	36·5	2190	65
Double 3 kg press	2 × 12 = 24	3·3	1·5	79·2	1752	142
Above as 6-kg press	12	3·3	1·5	39·6	2376	142

The firm of Schuchtermann & Kremer build Couffinhal presses in four sizes whose usual outputs and the power required for driving are as follows:—

	1-kg. Press	3 kg Press	5 to 6 kg Press	10 kg Press.
Output in 10 hours	About 20 tons	About 60 tons	About 95–116 tons	About 180 tons
Working power required	6–8 H.P.	16–18 H P.	25–30 H P.	50–55 H P.

The Couffinhal press is also applicable to the pressing of briquettes of less than 1 kg weight, but is scarcely to be recommended for this purpose. Many briquette factories have, for example, produced with a 3-kg. press, by the aid of corresponding mould crowns and stamps, small cubical briquettes of 50 × 55 × 68 mm. and 225 grm. weight, and in fact six briquettes were pressed and stripped at once by the use

of sectional moulds. Although the working output of the machine is about the same as when producing 3-kg. briquettes, the cubes are pressed under a much higher pressure, as shown by the following calculation:—

On the pressed surface of a 3-kg. briquette 110×220 mm.[1] = 242 sq. cm. there acts a pressure of 200 atms., or 200 kg. per sq. cm., or a total of about 48,400 kg. The sum of the pressed surfaces of six cubical briquettes of the above dimensions amounts, however, to $6 \times 50 \times 50$ mm.[1] = 165 cm. If this considerably smaller surface is subjected to an equal total pressure, the pressure acting on 1 sq. cm. amounts to $\frac{48400}{165}$ kg. = about 293 atms.

From this a much denser pressing of the cubical briquettes was assumed, but was an error, since a considerable proportion of this 293 atms. (almost one-third) was dissipated by the increased friction on the walls of the six small moulds.

The perimeter of the walls of the 3-kg. moulds is $2 \times 110 + 2 \times 220$ = about 660 mm., while the perimeter of the walls of six cubical moulds is $6(2 \times 50 + 2 \times 55)$ = about 1260 mm , *i.e.* almost double.

Further, it is favourable that the height of the friction surfaces is considerably higher in a 3-kg. mould (160 mm.) than in the mould for a cubical briquette. There is always a considerably greater amount of friction to overcome in pressing the latter, while the output in weight of briquettes produced is much less than in pressing 3-kg. briquettes, for the six cubes prepared at each stroke only weigh altogether 6×225 grm. = 1·35 kg., which is less than half the weight of a 3-kg briquette.

It is apparent from these simple considerations of what little advantage it is in general to produce small cubical briquettes by means of the Couffinhal press and other similar machine presses.

In conclusion, the Couffinhal presses fulfil the conditions mentioned above (p. 115) to a very high degree. Their relation to the modern revolver and toggle-joint presses will be further examined later (p. 156 and p. 176).

The Veillon (Roux-Veillon) Press (figs. 56 to 58).[2]—This press, invented by the French mining engineers Veillon and Roux, and perperfected by the designs of chief-engineer Marsais, is built by the "Société de Constructions Mécaniques" in Alais (France), and principally used in France. In Germany it does not seem to have been

[1] Without taking the rounding of the edges into account.

[2] S. W. Colquhoun, *Über Brikettfabrikation*, Glückauf, 1894, No. 112, p. 1893. A. de la Rocha, "Brikettpressen," *Braunkohle*, 1905, III., No. 42, p. 579.

applied up to the present. Like the Couffinhal press it makes use of a horizontal mould table in a similar manner, as well as an upper and lower press lever with corresponding stamps operated vertically, but differs principally in compressing both sides of the briquette at the same time and by hydraulic transmission of the driving power to the press lever.

Pressing the Briquettes (figs. 56 and 57).—The moving parts of the press are housed in a strong cast-iron frame A B C D E. The moulds of the circular revolving table F are filled with the briquette mass one after the other from a distributing vessel arranged above, by means of a four-armed stirrer. The upper press stamp J hangs from the upper double-armed lever G, while the lower stamp U[1] is carried by the lower single-armed lever H. Both levers obtain their motion from the principal crank-shaft Q by means of the driving pistons M and N. The shaft is driven by the two powerful-geared pinions P P. When the moving piston M attached to the short connecting rod L is pressed down, it displaces the water filling the two communicating vessels A A, which lifts the left piston N and with it the left-hand ends of the upper and lower press levers H and G. Now, since the points of support and rotation of the levers are respectively situated to the right and left of the corresponding press stamps, the stamps approach each other, the lower one is elevated and the upper one descends simultaneously into the mould on the table lying exactly between them, and the compression is completed. The moulds are provided with renewable linings which are arranged so that the section is somewhat larger at the bottom, in this way facilitating the removal of the briquette from below. Consequently, the lower stamp when rising should meet with a greater resistance than the descending upper stamp, because of the greater friction of the briquette mass against the walls of the mould if both stamps had equal strokes. This, however, is not the case. In order to obtain the necessary equal pressure on both sides, the length of the arms causing the motion of the upper and lower stamps has been made in the ratio of 3 : 2. The briquette is therefore not formed in the middle of the mould, but in the lower part—a circumstance which favours its removal.

The return motion of both stamps is effected by the crank shaft Q again lifting the left piston, when the displaced water returns and causes the fall of the right-hand piston N and of the corresponding heads of the two levers, the lower stamp U[1] goes downwards, while the upper stamp J is lifted out of the mould by the ascending right

arm of the upper lever. The stamps are effectively cooled by water running through them.

In order to assist the fall of the other piston during the ascent of the driving piston M, both pistons are connected to the beam R by tension bars, the tension bars from N being slotted in consequence of a possible difference in stroke of the two pistons. In order that the

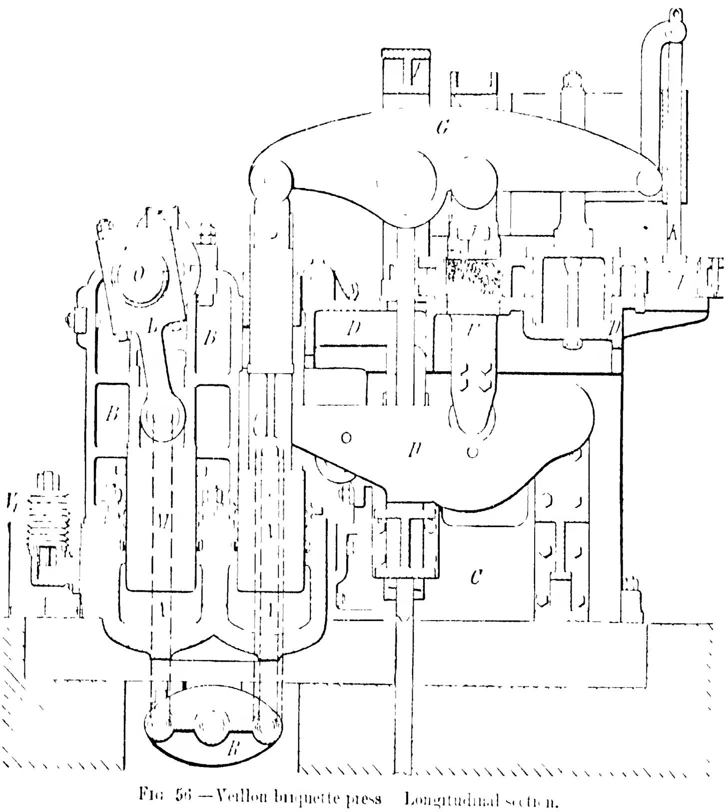


FIG. 56.—Veillon briquette press. Longitudinal section.

lower stamp shall not remain stuck in the mould during the descent of the right hand piston, its piston is suspended on a bar *s*, which is lifted at a given moment during every revolution of the main shaft by means of a projecting pin Z and the lever *h* or *h'* (figs. 57 and 58).

Turning the Mould Table.—For this purpose the mould table F is provided with upper and lower flanges (fig. 56), through which pass vertical steel bolts arranged on the produced centre lines of the various moulds (fig. 57). When the pressing of a briquette is completed and

the stamps withdrawn from the mould, the horizontally moving thrust bar O (figs. 57 and 58), whose right hand forked end engages with

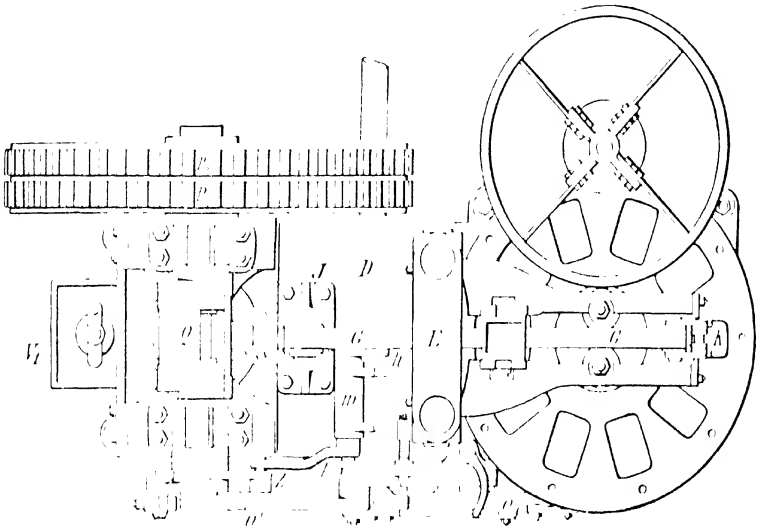


FIG. 57.—Veillon press. Plan.

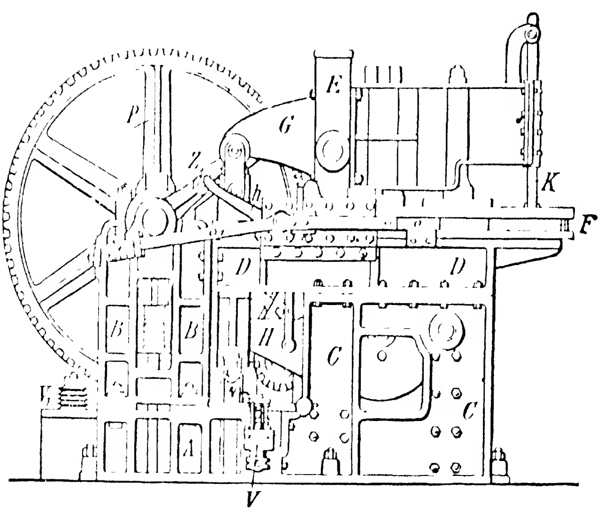


FIG. 58.—Veillon press. Side view.

one of the steel bolts, is displaced a little towards the right by the connecting rod O′, and in this way the table is set round by the distance between two neighbouring moulds. At its left end the thrust

bar can rotate about a vertical pin so as to follow the rotation of the mould table, and is returned to its proper position by means of a fixed spring provided for the purpose. During the return the mould table stands still and a new briquette is pressed in the mould brought between the stamps by the rotation, and so on.

Stripping of the completed Briquette.—As soon as the finished briquette in its mould has rotated through 180° by the repeated setting of the table and takes up a position diametrically opposite to the press stamps, it is pushed out below by the pushing-out stamp K (fig. 56), whose vertical moving rod is pressed downwards by means of a movable bent lever attached to the descending right arm of the upper press lever G. The briquette as it is pressed out is taken up either by a chute or band conveyor in the usual way.

Regulation of the Compression Pressure.—The hydraulic cylinders not only serve for the transmission of the thrust, but serve also as a pressure regulator by means of two safety-valves, of which V (fig. 58) acts as an outlet and V_1 (figs. 56 and 58) the inlet valve. These valves permit of regulating the pressure according to the briquetting mass and the required degree of cohesion of the briquettes to about 1 kg. per sq cm. of pressure surface, and of maintaining a uniform pressure during the operation. The normal pressure amounts to 200 kg. per sq. cm.

Types and Output of the Veillon Presses.—The presses are built in four types, according as briquettes of 3, 5, 7, or 10 kg. weight are to be prepared. Presses for large briquettes can also be used for the production of smaller briquettes by exchanging the table with ten large moulds in a circle (fig. 57) for a table with twenty smaller moulds in two series (as in the Couffinhal press), and using the corresponding stamps in two parts. The changing of the table occupies about four hours.

Under the pressure of 200 kg. given above, the normal output amounts to about 140 tons of briquettes per working day of ten hours. The weight of the press, exclusive of the appliances for mixing and distributing, is 40 tons.

Reliability and Suitability of the Veillon Press.—From the point of view of simplicity of design and attention, certainty in operation and quality of the results, the Veillon press has stood the test of practice. The compression pressure is of course not so great as in the Couffinhal and other systems. The action of the hydraulic system is excellent, but the turning mechanism is less suitable, and does not appear to be

so good as that of the Couffinhal system at all events. The press is specially adapted for large briquettes, for which it also has a high capacity. For small briquettes it is scarcely ever considered.

Revolver Presses (Middleton Press, Yeadon, Yeadon-Busse, and similar Presses).—The first revolver press, so called because of the mould disc turning in a vertical plane on a horizontal axis similar to a revolver, was designed by Robert Middleton of the Sheepear Foundry, Leeds, and in its original design[1] is still considerably applied in many home and foreign briquette factories.

The firm of Yeadon & Co., Leeds, then took in hand the various alterations and improvements, and introduced the press in its new form first in England in 1877, and later in other countries as the Yeadon press.

About 1895-96 fifty Yeadon presses were in operation in England; outside the country, according to English statistics, they were in operation in France (Compagnie des Mines de St Paulet in Gard and Ste Houillère de Vendin les Bethune, Pas de Calais), Belgium (Charbonnages de Bernissant, Peruwalz and Charbonnages réunis du Rien du Cœur et de la Boule, Quaregnon), as well as in the kingdom of Saxony (Oelsnitzer Briquettewerke Gluckauf since 1891 and Steinkohlenwerk Morgenstern in Reinsdorf since 1896) and in Austria (Trifailer Kohlenwerksgesellschaft in Krain).

At the beginning of the year 1900 the Yeadon press[2] was used in over ninety installations, with a total yearly output of over 2,000,000 tons, in England, Scotland, Belgium, France, Spain, Austria, Germany, Italy, Russia, India, China, Australia, West Africa, North and South America.

In Germany, the use of the revolver press in its original form or in the improved Yeadon design was, until the spring of 1908, limited almost exclusively to the colliery districts of the kingdom of Saxony and Upper and Lower Silesia, where a total of twelve presses found application. Its use in Lower Rhenish Westphalia had not yet commenced. The production of the Yeadon press was first taken up in Germany by the Konigin-Marienhutte at Cainsdorff in Saxony, and then by the Zeitzer Eisengieszerei und Maschinenbau Akt.-Ges. at Zeitz.

Busse, who was at that time chief engineer at the Zeitzer Eisengieszerei, introduced several improvements which, since about 1901-2, have found application in the revolver presses constructed by that firm. This new type, which will be designated briefly as the Yeadon-Busse press in the following pages, also goes under the name of Zeitzer press in several districts. With some slight alterations it is also built by the Braunschweigisch Maschinenfabriken Akt.-Ges. at Alfeld on

[1] Gluckauf, Essen, 1896, No. 15, p. 294.
[2] According to a prospectus of the Konigin Marienhutte at Cainsdorff in Saxony.

the Leine and by the Maschinenbau Akt Ges. Tigler at Duisburg-Meiderich.

In recent times the Zeitzer Eisengieszerei have still further perfected the Yeadon-Busse press from the point of view of certainty of operation and capacity. Since the original Middleton press, which is now regarded as obsolete, never found much application in Germany, a complete description can well be omitted here.[1] It will be sufficient to indicate its principles, which have been largely retained in the later types of Yeadon and other presses.

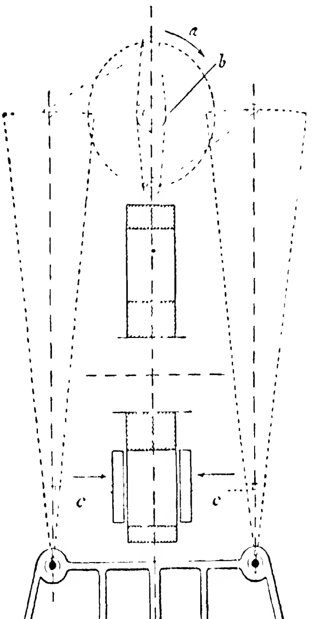


Fig. 59.—Diagrammatic representation of the principles of compression of the revolver press.

The Principle of the Revolver Press. The revolver press differs from the previously described toggle joint press of Middleton or Middleton-Détombay which works with a one-sided compression and a horizontal mould table—very considerably, above all in having a two-sided compression of the briquetting mass, and again in having a vertical revolving table. It differs from the other machines with double pressing mainly in the vertical arrangement of the mould table and the resulting horizontal motion of the pressing and stripping stamps, as well as by the application of a special charging stamp. The two-sided compression is effected, as will be best seen from the diagrammatic sketch (fig. 59),[2] by two upright one-armed levers which are simultaneously moved backwards and forwards in opposite directions from the beam *b* by two parallel connecting rods. When they approach each other as a result of the rotation of the beam in the direction of the arrow *a*, they drive both the press stamps *c* attached to them below into the mould on the vertical revolving table previously partially filled with the briquetting

[1] It is minutely described and illustrated by Philip R. Bjorling in *Briquettes and Patent Fuel*, London, 1903, pp. 78–84, figs. 70 to 74.

[2] According to *Z. Braunkohle*, 1905, iii., No. 41, p. 570.

mass. After the compression of the briquette mass they again draw apart and withdraw the stamps from both sides.

Yeadon Revolver Press (figs. 60 to 64). The illustrations show the press according to the drawings of the Konigin Marienhutte at Cainsdorf in Saxony.[1] After each intermittent rotation of the mould table M (revolver), fig. 60, the heated briquette mass charged into one of the

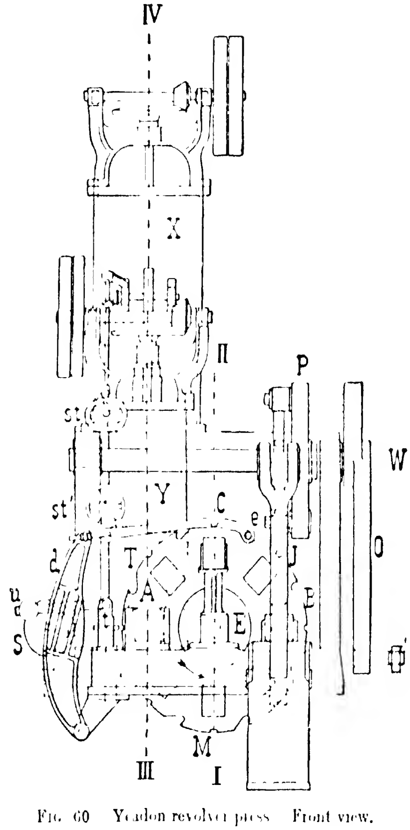


Fig. 60. Yeadon revolver press. Front view.

eight moulds, usually with six divisions, from the cylindrical steam kneaders X and Y, is slightly compressed at A, while at the same time a briquette is finished, pressed, at C and another one is pushed out at B. Individually these various operations are carried out as follows:—

The admixture and conveyance of the briquetting mass is effected

[1] E. Treptow, "Das Brikettieren der Steinkohle im Konigreich Sachsen," *Sachs. Jahrbuch* auf das Jahr 1907, p. 35, figs. 1–4.

in the cylinders X and Y (fig 61) in the well-known way by means of vertical shafts with horizontal stirring arms *r*. Heating is effected by steam superheated to about 225°, issuing from numerous holes in the bent annular tube *a*. The passage of the mass from the upper to the lower cylinder can be regulated by the hand-wheel *st*, which operates

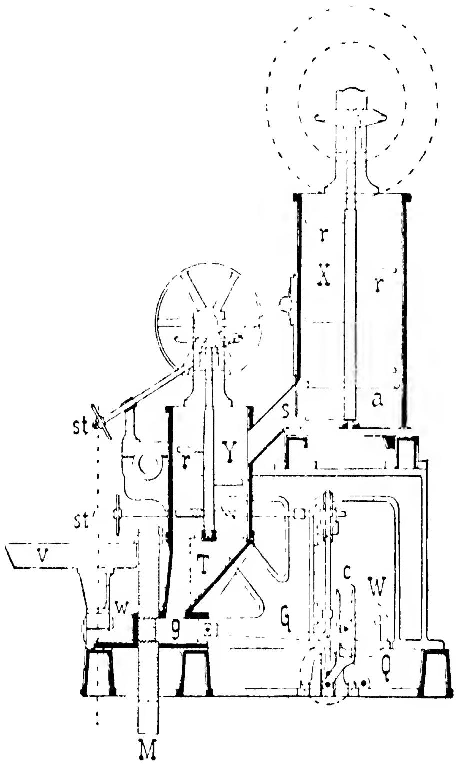


FIG. 61. Yeadon press. Section on III–IV. (fig 60) through the charging stamps.

the rack and pinion controlling the slide *s*. From the cylinder Y the mass slides through the hopper T to the filling channel.

Filling and Preliminary Pressing (figs. 61 and 63) is done by means of the charging or filling stamps *g*. The stamp is moved backwards and forwards in the filling channel by the crank F, the link *c* and the thrust bar G, driven by the main shaft W, pushes the mass into the mould standing immediately in front on the revolving table and presses it against the fixed abutment *w*. By means of a regulating appliance *st′* the fixed point of the thrust bar G in the link *c* can be

raised or lowered and the thrust of the filling stamp correspondingly lengthened or shortened. The stroke is greatest when the thrust bar has a horizontal position and a large quantity of the mass is pushed into the mould and subjected to a strong preliminary pressure. At an inclined position as shown in fig. 61, the degree of filling and compression is much smaller.

The compression (figs. 62, 63, 64 and 60) is effected in the manner already diagrammatically indicated above by the press stamps H H led horizontally through both sides of the frame of the machine in conjunction with the press levers J and K and the tension bars *k* con-

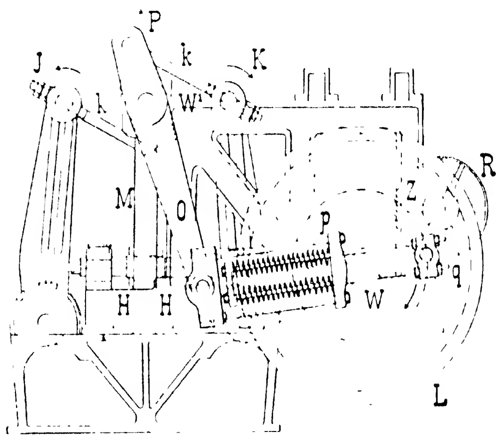


FIG. 62.—Section through I—II (fig. 60) seen from the left at the moment of greatest compression.

necting them, the equal armed beam P and the unequal armed swinging lever O keyed on to the same shaft W', and the spring connecting rod *p*, which is attached to the long lower arm of the lever O.

The connecting rod *p* is moved to and from the crank *q* of the crank disc L attached to the main shaft W, and causes the whole pressing phenomenon to take place in an elastic manner.

The stroke of the press stamp can be increased or diminished by suitably varying the length of the tension bars *k* by means of the nuts and lock nuts provided. Constant spraying with water keeps the stamps clean and cool.

For stripping the briquettes *b* into the channel *r* (figs. 64 and 63) a piston ram is provided. Its stroke is caused by the bent lever N and the cam D fastened to the main shaft W. The bent lever is fixed under the main shaft so that it can rotate, and is driven

forward at every turn by the cam against the pressure of the spring f, which causes the return of the lever as soon as the cam releases it.

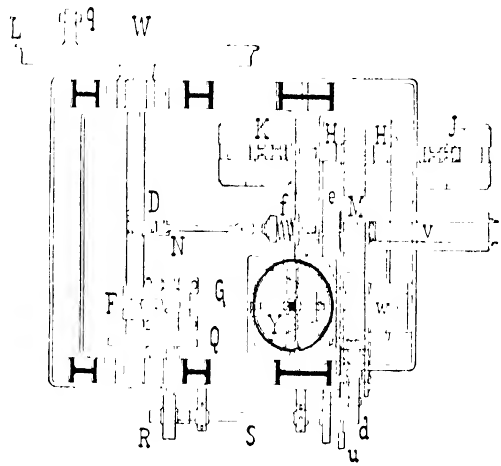


FIG 63 Yeadon press Plan.

Turning the Mould Table (figs. 60 and 63)—After each withdrawal of the stamp the table is rotated through 45°. For this purpose grooves

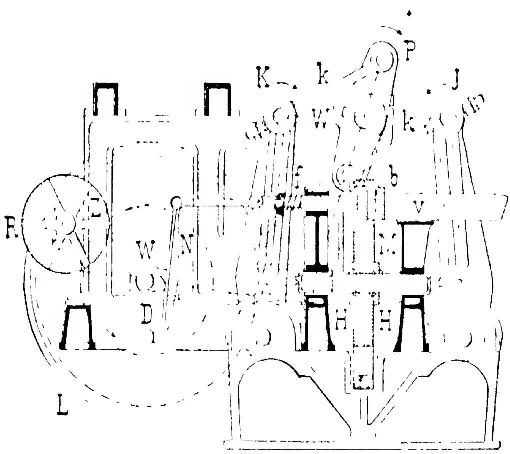


FIG. 64.—Yeadon press View from the right.

are cut at the edge of the table midway between two moulds. A bolt e, whose ends are carried by two bars, engages in the slots at each turn. The other ends of the throw-bars are fastened to a link d pivoted at the bottom. When the link moves towards the left from

its extreme right position, indicated in fig. 60 the mould table is turned through a sector at the same time. The drive is effected from the main shaft W, the gear wheels Q, the two worm wheels R, and the side shaft S, which sets the link *d* swinging by means of the sliding pieces.

The fixing of the mould table during the compression is done in such a manner that the horizontally moving bar *t* is pressed into one of the rectangular grooves in the edge of the table midway between two moulds by means of the loaded bent lever *u*. When the mould table revolves the lever *u* is lifted by means of an eccentric on the shaft *s* and the bar *t* is drawn out of the slot. The drive of the whole press is obtained from the belt pulley R (figs. 62 and 64) and the gear wheel Z on the same counter shaft. The gear Z engages in the toothed crown of the crank disc L, and in this way drives the main shaft W with the appliances fixed upon it. The number of strokes or compressions per minute is usually fourteen.

Various Sizes and Outputs of the Yeadon Presses.[1] The Yeadon presses are manufactured in various sizes for the production of 10, 25, 50, 100 and 200 tons of briquettes per shift of ten hours.

Yeadon Busse Revolver Press (figs. 65 to 70).[2] The changes which the Zeitzer Eisengiesserei und Maschinenbau Aktiengesellschaft made about 1901–2 in accordance with the proposals of chief engineer Busse, had in view the rendering of the press more certain in operation and making the press need fewer repairs.

The most important of them are as follows:—

(1) The design is strengthened considerably and the number of strokes increased up to sixteen per minute.

(2) The crown gear wheels and the principal drives are provided with double helical teeth (fig. 70) and the toothed rim of the crank disc L (compare fig. 64) is made removable in virtue of the fact that during each revolution the same teeth are subjected to the strain.

When a group of teeth is worn out, the crown is displaced by ¼ of the circumference, and the next group allowed to come into play, and so on.

(3) A comparison of the front view of the older press (fig. 60) with that of the new press (fig. 65) shows the filling of the briquette mass at A is moved from the left to the right side, and accordingly, the

[1] Prospectus of the Königin Marienhütte Aktiengesellschaft, Cainsdorf, Saxony.

[2] E. Treptow, "Das Brikettieren der Steinkohle im Königreich Sachsen," *Sachs. Jahrbuch*, 1907, p. 39A, figs. 6–10.

whole of the compression mechanism is moved from the right to the left side of the mould table.

(4) The charging vessel Y (fig 66) fed from the upright steam kneader X through the opening of the slide *s*, contains a stirrer arranged on a horizontal shaft to convey the mass to a charging stamp *g*

(5) The distributor *h* (fig 66) can be built between the charging stamp and the mould table. It is a frame of the section of the

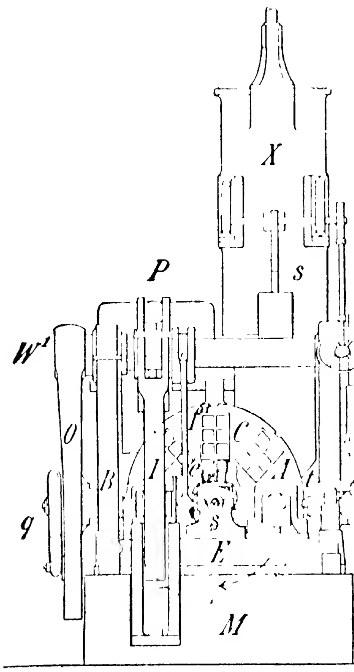


FIG. 65 -Yeadon-Busse revolver press. Front view

divided mould provided with ribs which are sharpened at the side of the charging stamp (D R P., 138976).[1]

The object is to obtain uniform distribution of the mass in the moulds and a lower inclination of the ribs of the mould as well as the front surface of the press stamp, which increases the efficacy of pressing

(6) The thrust bar G of the charging stamp *g* (fig 66) is protected against breakage by a strong spiral spring and for the same object the abutment plate *w* on the other side (see also figs. 69 and 70) can be adjusted by a spring.

[1] For the later changes in the distributor see p. 151 below.

(7) The press levers I and K (fig 67), as well as the press stamps H H, are made of cast steel, the corresponding shafts and tension bars are forged from steel, and are consequently capable of offering a much greater resistance to shock.

(8) The pushing-out stamp U (fig 67) is guided twice, and is driven from the main shaft W by means of the cam D (fig 68) and the lever N, which can revolve about the pin *c* and is provided with three pro

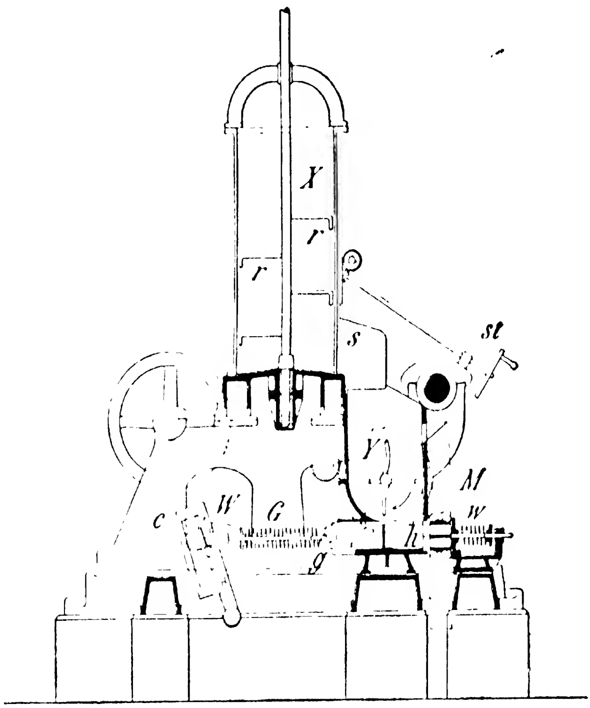


Fig. 66.—Yeadon Bros.' press. Section through the stirring and filling arrangements

jections *m*, *n*, and *o*. The nose *m* only serves the purpose of ensuring engagement with the pressure roller attached to the cam. When the roller rolls along the upper portion of the gliding surface between *m* and *n*, N turns towards the right and the stamp is pushed forward, but when it engages with the nose *n*, which is pushed downwards by the further revolution of the cam, the return of the stamp is obtained.

(9) The turning of the mould table (figs 65, 69, and 70) is not carried out at its circumference, but by the intermittent slow revolution of a governing wheel s (fig 69) keyed to the shaft of the mould table, actuated by the vertical tension bar *f* and the governing bolt *e*.

The up-and-down motion of the tension rod is obtained from the main shaft W with the aid of the equal armed lever on the shaft W′, the inclined connecting rod f (fig. 67), and the eccentric d.

The control wheel S, provided with eight teeth, is built in two sections in the direction of the axis in such a manner that a sliding ring carried by the ratchet e can find a place. Each time the tension bar f' is lifted, the mould table makes $\frac{1}{8}$ of a revolution, and

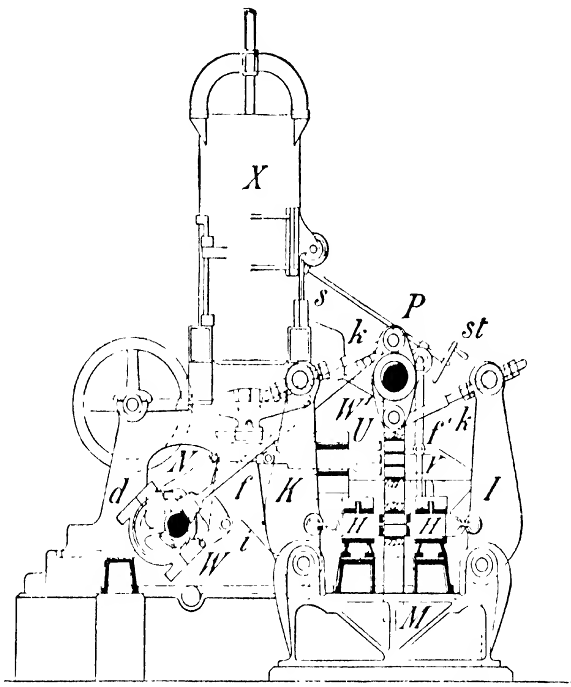


Fig. 67. Yeadon Busse press. Side view and longitudinal section through the pressing and stripping appliances.

when f' falls, the controlling ratchet engages with the next tooth of the controlling wheel.

(10) To hold the mould table fast during the compression, the loaded bent lever u at the right (figs. 65 and 69) forces the bar t into a groove cut into the circumference, but withdraws it during the period of rotation. For this purpose the right arm of the lever u is lifted when necessary by means of the two-armed lever y and the cam x situated on the main shaft W.

Sizes and Outputs of Yeadon-Busse Press of Zeitz Origin.—The

Zeitzer Eisengieszerei has delivered these presses in two sizes, mostly consisting of—

(1) Small presses, preparing four briquettes, each of 1 kg. weight at one compression; and

(2) Large presses, producing six briquettes, each weighing 0·7 kg per compression. Under normal conditions of working, *i.e.* 13 to 15 compressions per minute, this gives an output of 5 to 6 tons per hour, or 50 to 60 tons per day of good briquettes, exclusive of waste. The quantity of broken briquettes produced is not inconsiderable, especially when the moulds and stamps become badly worn.

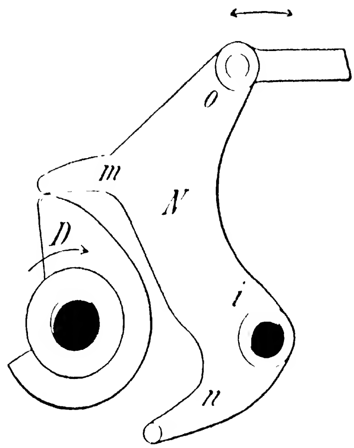


FIG. 68.—Motion of the pushing-out stamp Enlarged.

New Zeitz Revolver Presses.—Recently the Zeitzer Eisengieszerei has added the following important improvements to the Yeadon Busse press:—

(1) By the introduction of a new turning appliance, the number of compressions can be increased to twenty-five per minute, and the output increased by about 50 per cent.

(2) By alteration of the distributor (*h* in fig. 66), which does not adequately meet the demands, or only does so after long experiments. With the new distributor the filling up of the press stores again becomes a simple matter. These presses are also made in two sizes. According to the statement of the firm, the outputs, together with the weights and sizes of the briquettes, are as follows:—

Model I				Model II			
No.	Briquette. Weight.	Briquette. Dimensions.	Output in 10 hours.	No.	Briquette. Weight.	Briquette. Dimensions.	Output in 10 hours.
	kg.	mm.	tons.		kg.	mm.	ton.
1	0·7	70 × 70 × 135	40	1	0·7	70 × 70 × 135	60
2	1	80 × 80 × 135	55	2	1	80 × 80 × 135	80
3	3	150 × 130 × 135	40	3	1·5	110 × 85 × 135	80
4	4	165 × 165 × 135	55	4	3	150 × 130 × 135	80
				5	5	175 × 175 × 135	65
				6	6	220 × 170 × 135	80

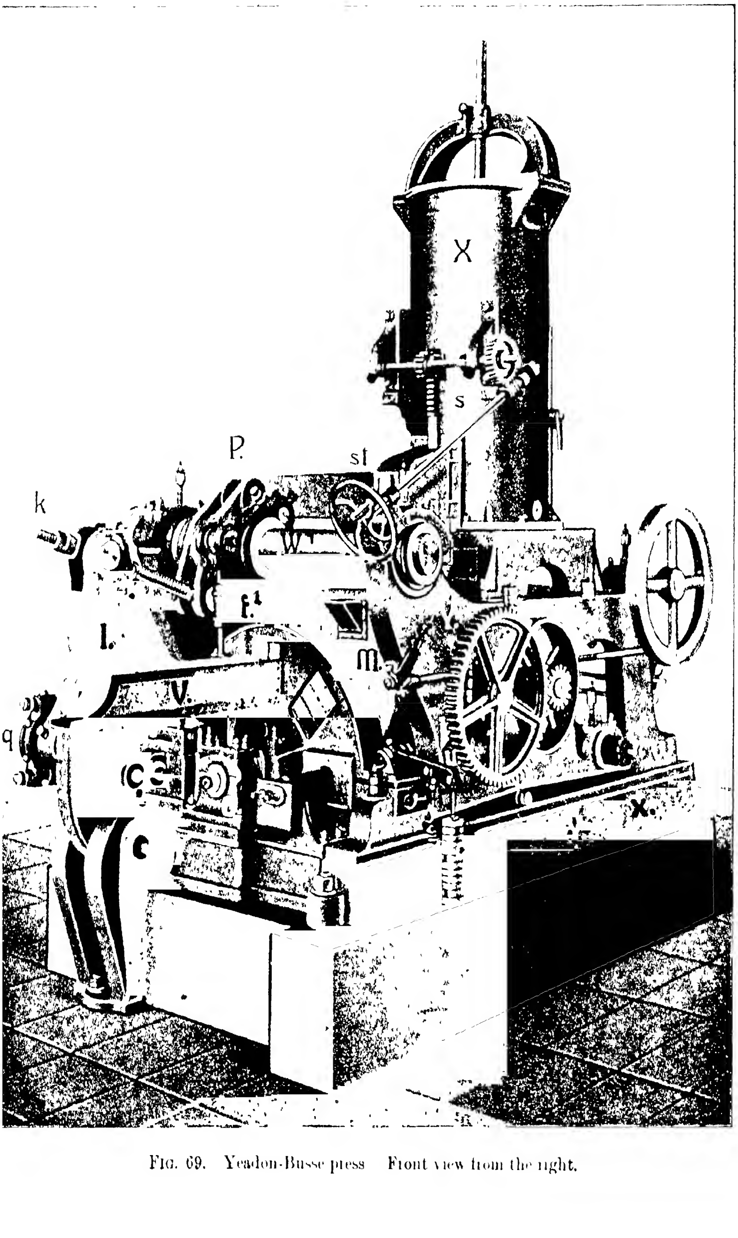


FIG. 69. Yeadon-Busse press Front view from the right.

Revolver Presses of the Braunschweigisch-Hannoverschen Maschinenfabriken A.-G.—The revolver presses from this works, situated at Alfeld on the Leine, are, for the most part similar to those of the Yeadon design modified by Busse and described above. They only show certain specialities in a few parts. According to data supplied by the firm the presses are made in three sizes whose outputs, with the weights of the briquettes, can be seen from the following table:—

Model I		Model II		Model III	
Weight of a Briquette	Output in 10 hours	Weight of a Briquette	Output in 10 hours	Weight of a Briquette	Output in 10 hours
kg	tons	kg	tons	kg	tons
0·5	20	1	50	3	100
0·75	30	1·5	50	6	100
1	40	3	50	12	100
2	40	4	67		
4	40	8	67		
5	50				

The number of compressions can be raised to eighteen per minute, while the pressure during the principal compression can be raised to 400 kg per sq cm, and even more if required.

Revolver Presses of the Maschinenbau A.-G. Tigler. This firm at Duisburg-Meiderich, formerly known chiefly for the construction of the toggle joint presses, to be dealt with below, has recently taken up the construction of revolver presses known as the Busse-Tigler patent presses, and which differ but little from the Yeadon Busse type. According to the account of the firm, they can be delivered in the following sizes:—

Model P. B. I		Model P. B. II		Model P. B. III	
Weight of a Briquette	Output in 10 hours	Weight of a Briquette	Output in 10 hours	Weight of a Briquette	Output in 10 hours
kg	tons	kg.	tons	kg	tons
0·25	10	0·75	60	1	80
0·50	35	1	80	2	105
0·75	40	1·25	100	3	120
1	55	3	80	5	150
2·5	68	6	80	10	150
5	68				

Testing and Adaptability of Revolver Presses.—The construction of the revolver press, even with the introduction of the modern im-

provements, is fairly complicated and not very compact, the number of the moving parts being large. Consequently, these presses soon begin

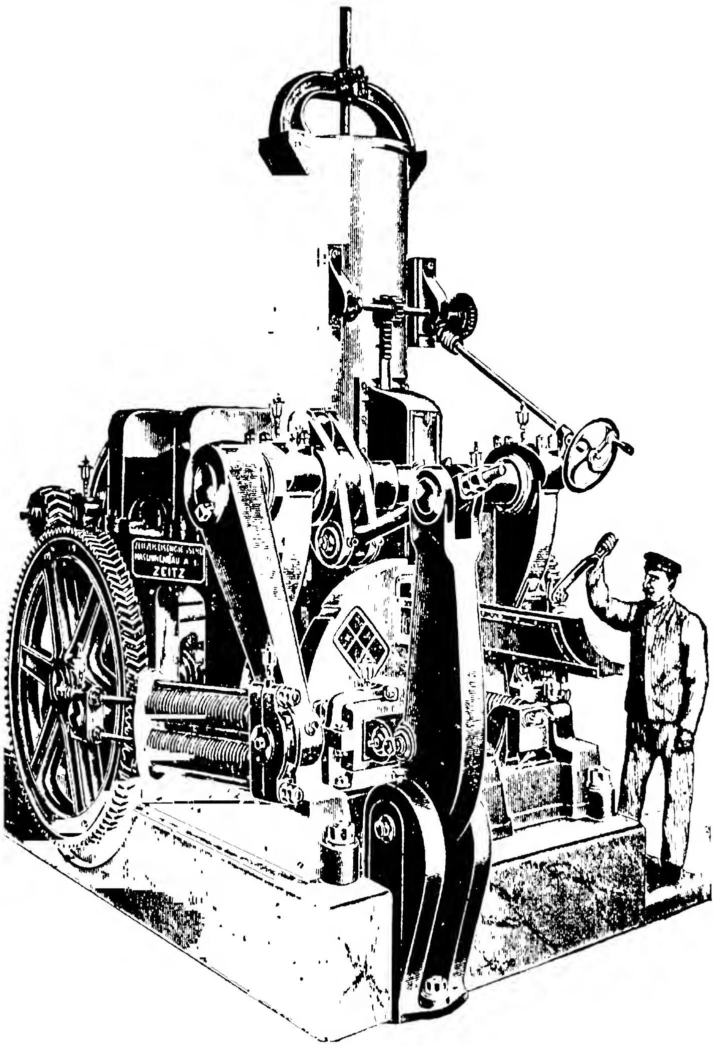


FIG. 70. Yeadon Busse press. Front view from the left.

to wear and need repairing relatively quickly—at all events much sooner than in the case of the Coulinhal presses, which are much more simple in construction.

The parts most subject to wear are:—the rammer or charging stamp

with the lining of the charging box, the eccentric turning the revolver disc, and, further, the mould spaces and the press stamps. The rapid wear of the latter parts is, however, mainly caused by the general application of moulds and stamps in several parts, permitting of the formation of four to six briquettes at one compression in revolver presses for small and medium-sized briquettes. The larger the number of sections in the mould and stamp, the greater the total surface of the mould walls and stamps affected and the greater the frictional resistance to be overcome in pressing especially with hard coal. Consequently, these parts become worn out very rapidly.

A further cause of the rapid wear is that under certain conditions the turning of the revolving table is not quite free from defects, and faults are liable to develop rapidly, especially with the older Yeadon turning mechanism. The result is that the stamps are subject to a shock when entering the mould box leading to the widening of the front portions by the breaking away and rounding off of the edges and corners. An unpleasant consequence of this is, in addition to the excessive waste and loss of the briquetting mass, the production of briquettes whose edges are broken away. In order to obviate these evils as far as possible, it is necessary to handle and repair the press carefully, and to frequently change the parts which suffer most. Of course, this is rendered difficult because these parts, especially the rammers and the rammer box, are not very readily accessible.

In other respects the newer improved revolver presses, with good attendance, show enormous advantages with regard to certainty in operation, uniform and powerful compression, and capability of output. Special attention is to be called to a particular advantage of this press over all the systems with a horizontal mould table: the briquettes can be provided with characters and indentations on both sides, and, in addition rounded edges can be provided on all sides, so that the loss resulting from the rubbing away of the edges during loading or storage can be prevented.

The outputs, up to a briquette weight of 1½ kg, for which these presses are mostly built and best adapt themselves, are relatively large, but flat forms, 50 to 70 mm, cannot be prepared in them, since the height of the briquette depends upon the height or thickness of the revolver table. For large briquettes of 3 kg weight and above, considerable outputs can also be obtained, but for this purpose revolver presses are not so much considered, partly on the above grounds and because of the higher working costs as compared with the Couffinhal

presses on the one hand, and because of lower outputs when compared, for example, with the toggle-joint presses of modern construction.

The working experiences obtained at a briquette works in Upper Silesia are of special interest. Here three Yeadon-Busse presses (from the Zeitzer Eisengieszerei) and four Couffinhal presses (Schuchtermann & Kremer) have been in operation next to each other for years producing 1-kg briquettes

The following results were obtained.[1]—

1. Both systems of presses produce about the same outputs.

2 The revolver presses require frequent repairs—mostly in the parts previously indicated, the Couffinhal presses, however, seldom require repairs.

3. The revolver presses are only able to work up the local coals in the finely ground state with soft pitch. This is dearer than hard pitch and leads to difficulties in conveying and working in summer because of its low melting-point. The Couffinhal presses are not subject to any of these disadvantages.

4 As the briquettes leave the revolver presses they are still relatively soft, therefore they are less resistant right up to the time when they are mostly handled—during loading—than the finished briquettes from the Couffinhal presses.

5 The difference in the total costs amounts to almost 1·60 marks per ton of finished product, to the disadvantage of the revolver press.

6 However, in a briquette factory built by the Zeitzer Eisengieszerei in Upper Silesia in 1903, equipped with a Yeadon-Busse press and later with a toggle-lever press of the older Tigler-Surmann patent operating side by side, and having a total output of 11 tons of 1-kg briquettes per hour, the revolver press has proved the better of the two up to the present.[1] The costs of its repairs are not very high. For attention, a press overlooker and a man to remove the discharged briquettes on to the loading band are sufficient The finished briquettes have a good appearance, and are sufficiently strong and capable of storing to withstand the railroad conditions.

The toggle-lever presses show higher costs for repairs and also higher costs for attendance (a press overlooker and two men for removing the briquettes to the band conveyor are necessary). At the same time, the output per hour is about 1 ton less (5 tons as against 6 tons), and the manufactured product is not so good as regards uniformity and durability.

[1] According to an account by the works management, spring 1908.

With regard to the relations of the new Zeitz revolver presses and toggle joint presses (Schurmg patent) more will be said below (p 175), after the description of the latter system

Toggle-lever Presses with Double Pressing The application of bent levers for pressing was carried out to a certain extent in the old Middleton-Détombay machine (p 119, figs 16 and 17) The modern toggle-joint presses to be described here differ from that machine principally in that they apply equal pressures to two opposites sides of the briquette simultaneously This is effected by means of a double toggle-joint and upper and lower cross heads which are connected together by powerful tie bars Further they are all, with the exception of the Sutcliffe press, provided with a fixed mould table containing closely lying moulds, and a moving charging box instead of the customary revolving mould table

Such toggle-lever presses were introduced into the briquetting industry by the Maschinenbau-Aktiengesellschaft Tigler in Duisburg-Meiderich, after the same firm had supplied presses of similar construction for the production of shale blocks slag blocks, artificial sandstones and so on.

It is true that the first experiments on the application of these presses[1] at the Dahlhauser Brikettwerk and the Zeche Margareta failed because of various deficiencies Further, some installations for briquette works on the Upper Rhine did not act as pioneers until the firm called the attention of wider mining circles to their methods of pressing in the year 1902 by the introduction of a small coal briquetting plant at the Dusseldorf Exhibition Shortly afterwards they were commissioned to construct a new briquette factory, provided with new toggle-lever presses (Tigler-Surmann patent), for the Zeche Holland III IV at Wattenscheid In the following year came further orders from this company, as well as from other works: for the briquette factory of Matthias Stinner, Mannheim, the Kons. Furstensteiner Gruben-Waldenburg in Silesia, the "Elbe" briquette works at Harburg, the Kgl Berginspektion I at Konigshutte in Upper Silesia, the Gewerkshaft Deutscher Kaiser Bruckhausen, Rhine, the Gelsenkirchener Bergwerks Aktiengesellschaft (Schacht Hamburg and Zeche Bonifazius), and also others in foreign countries (Russia, Belgium, etc).

The Masch Akt-Ges Tigler had, up to the summer of 1908, according to its own accounts, delivered altogether for the production of coal briquettes 42 toggle-lever presses (32 large and 10 small), and, further, 6 small presses

[1] *Niederrheinisch.-Westfal. Sammelwerke*, vol IX, 1905, p. 641.

(as high pressure presses) for coke briquettes, and 3 large and 1 small presses for ore briquettes. To this must be added about 60 toggle-lever presses for dry pressing bricks, tiles, or lime sand stones.

The first toggle-lever press at the Zeche Holland III/IV. had proved quite defective from many points of view. As a result of this and other experiences, the design of the later installations has been much improved by the firm mentioned, even in recent times. Latterly the Zeitzer Eisengieszerei und Maschinenbau Aktiengesellschaft has taken up the production of improved toggle-lever presses according to Schuring's patent. The firm of Sutcliffe, Speakman & Co., in Leigh, Lancashire, builds on its own system toggle-lever presses with a revolving mould table. Bent-lever presses of German origin have to carry out the following operations either simultaneously or one after the other:—

1. To fill a movable charging box with briquetting material from a worm conveyor.

2. To push forward the filled charging box and the last of the pressed briquettes lifted out of the mould chamber.

3. To withdraw the lower compression stamp, in order to again open the mould chamber.

4. To push down the fresh briquetting material into the mould chamber by means of the descending upper compression stamp which is then lifted up again.

5. To effect the return of the empty charging box, and a preliminary compression of the material by a blow from the upper stamp.

6. To effect the simultaneous and main compression of the briquettes by means of the upper and lower stamps.

7. To lift the upper stamp and to push out the briquettes upwards by means of the lower stamp, whereupon the charging box again charged with briquetting material in the meantime (see 1 above), is again pushed forward, and so on.

The two systems of German toggle-lever presses will first be dealt with in reference to the above points.

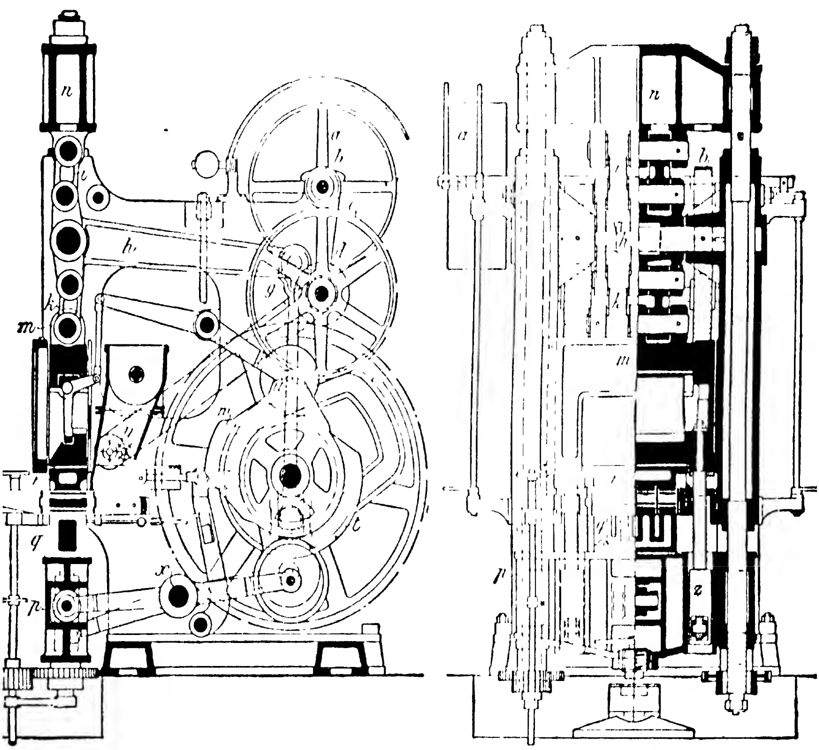
Toggle-lever Presses of the Maschinenbau Akt.-Ges. Tigler. Tigler Presses.—A description of the first and now obsolete Tigler press[1] for coal briquettes may well be omitted here. The construction of the modern presses is to some extent considerably different according as small or large briquettes are to be produced.

[1] It is described in *Niederrhein.-Westfal. Sammelwerke*, Bd. ix., 1905, p. 349, and illustrated in fig. 307, *a* to *c*.

The presses for large briquettes are again different: (A) in certain old types; (B) in certain modern types.

These presses carry out the requirements enumerated above as follows:—

(A) *Large Tigler Press of the Old Type* (fig. 71).[1]—Most of the large presses produced up to about the year 1906 belong to this type. The



Cross section. Front view and longitudinal section.

Fig. 71.—Large Tigler bent lever press, older type.

drive is effected by means of a belt pulley *a* which sets in rotation the cranked axle acting as the main shaft, with the aid of the gear wheel drive *b*, *c*, *d*, and *e*.

Accomplishment of 1 (p. 158).—To fill the charging box from worm conveyor, the charging hopper *g* is provided. Into it are built two horizontal stirrers whose axles are fitted with wings and driven by means of a Gall chain. The briquetting material set in motion by

[1] *Ibid.*, p. 652, and fig. 308, *a* to *b*. The press is designated "Tigler Press No. 1."

this means is allowed to fall uniformly into the large opening of the box when the latter is exactly under the hopper, as in the left of fig. 71.

2. If we consider the divided upper press stamp *r*, which in the figure still dips into the mould, to be lifted and the compressed briquette pushed out of the mould chamber by the ascending lower compression stamp *q*, so that the briquettes are on a level with the upper surface of the mould table, the full charging box, with the briquettes, can now be pushed forward into the empty space. This is effected by means of a lever connected to the box and fixed below so as to be capable of turning. At its right-hand end is a roller which runs in a curved slide keyed to the main shaft and moved to the left when the large projection on the curved slide (directed towards the right in fig. 71) has revolved through about 180°.

3. At the moment when the charging box stands over the compression mould, the lower cross head *p*, with the divided lower stamp *q*, descends in order to reopen the mould chamber. The descent is obtained by a single- and a double-armed lever situated left and right on the axle *x*. At the free end of the one-armed lever is a roller which is pressed by the weight of the cross head *p*, etc., against an irregular disc *w* which lowers and holds the lever in the same position or raises it according to the form. In the latter case the lower cross head with its stamp is lowered by its own weight.

4. Since in the first Tigler presses the filling of the mould chambers from the charging boxes immediately above by the simple falling of the briquetting material, only proceeds uncertainly and irregularly, giving rise to many poor briquettes, care is taken in the later presses that the charge is pushed down from the box into the moulds by the upper descending compression stamp. For this purpose the irregular disc *w*, which, by means of a roller and a transferring lever controlled by it, sets to work the compression members with the upper stamp *r*, has been provided with a hollow on the circumference, in which the roller *u* runs during the interval of rest of the charging box. In this way the upper stamp is allowed to travel downwards, and, when the roller leaves the hollow, the stamp is lifted again.

5. The return of the charging box, emptied by the upper stamp, is brought about by the arrangement described under 2, when the projection of the curved slide again revolves to the right.

6. The irregular disc *w* on the main shaft again acts on the roller *u*, the levers, and the upper compression member, so that the latter

causes the upper stamp to fall into the mould with a striking velocity giving rise to a certain amount of compression

7. The principal compression is now effected by means of the two linked levers *i* and *k*. These are connected by a toggle-joint to the principal lever *h*, which is set swinging upwards and downwards by the connecting rod *g* attached to the crank of the main shaft. Further, the linked levers are connected above with the cross-head *n*, which is capable of vertical movement, and below with the slot *m* in the stamp, by means of bolts. The raising and lowering of the cross-head *n* is communicated to the lower cross-head *p* carrying the lower pressure stamp by the powerful tension bars (right of fig. 71) fixed at both sides of the machine. In the same way as the straightening of the toggle-joint lever lifts the bolt of the upper joint of the lever, the bolt of the lower link *k* presses the stamp slides *m* down in the guides situated in the framework. In this way the upper compression stamp *r*, fastened to the lower end of the bolt, is pressed on to the material to be pressed in the mould chamber below. Simultaneously the lower cross-head *p* is elevated by means of the iron tie-rods at the two sides, causing the raising of the lower compression stamp which effects the lower pressing of the briquette.

8. Next follows the return of the upper stamp to the elevated position by the return of the toggle-joint lever to the bent position. To accelerate this elevation the intermediate piece inserted between the stamp slides *m* and the pressure member of the upper stamp is thrown out of gear. This purpose is effected by the irregular disc *t* on the main shaft, the roller *u*, and the system of levers connecting it with the compression member. Since the front ends of the double lever engage in openings in the bar *z*, supporting and clamping the compression piece with the upper stamp *r*, the rapid elevation of the pressure member can be effected independently of the motion of the main slides. The lifting of the lower cross-head *q* follows immediately by the combined action of lever, roller, and irregular disc, similar to the one described above. At the same time this results in the finished briquette being pushed upwards out of the mould chamber by means of the lower compression stamp travelling upwards with the cross-head.

The charging box, which has been refilled in the meantime, is then again pushed forward, and so on.

In order to regulate the height of the filling of the mould chambers in the later Tigler presses, the lower cross-head is provided at the bottom with strong nut and screw and powerful thread, which can be easily and accurately adjusted by means of a hand-lever capable of

being fixed. The regulation of the pressure for various heights of briquette is effected at the lower stamp by varying the position of the nut on the tension screw with the aid of a geared drive set in motion by means of a Gall chain and a hand-wheel.

Since about 1906, presses of the design described have only been built with the improvements dealt with in the following paragraphs:

(B) *Large Tigler Press, new Type* (figs. 72 and 73).—This type, designated "Model V.," which has been almost exclusively applied by the Masch. Akt.-Ges. Tigler of recent years, differs from the older machine principally in that the transfer of motion from the crank-shaft to the toggle-joint lever (previously a fixed bar *g*, fig 71) is now, as will be seen from the following description and illustrations, effected by means of two tension rods provided with springs.

Drive and Compression.—The drive of the press results from the belt pulley 1 and the gear wheels 2 to 5 This sets in rotation the crank shaft (main shaft) 6 and at the same time the crank discs 7, situated on both sides, to whose crank pins 8 two connecting rods fitted with springs are attached. The connecting rods transfer to the toggle-lever 10 a uniform up-and-down motion, which is transmitted in turn to the link levers 11 and 12 connected to them by means of a toggle-joint. These link levers are connected by means of bolts to a vertically displaceable cross-head 13 on one side, and on the other side with the stamp slides 14. The lifting and lowering of the cross-head 13 is transferred to the lower cross-head 16 carrying the lower compression stamp 17 by means of powerful tie-rods 15 The bolt of the lower link of the lever 11 presses down the stamp slides in their guides between the framework to the same extent as the bolts of the upper link 12 are elevated. In this way the divided upper stamp 18 attached to the stamp slides is forced into the compression mould 19, while at the same time the lower cross-head is lifted by means of the tie-rods 15 and effects the lower compression

The lifting of the upper stamp and the pushing of the briquettes from the mould takes place exactly as in the earlier type. In the first place, the intermediate piece 21 is thrown out of gear by means of the tension bar 24, the two-armed lever 23, the roller 22, and the irregular disc 21ᵃ. Then the rapid elevation of the pressure member 20, with the upper stamp 18, is effected by lifting the two supporting rods 30 by means of the double lever 27–28 situated on the axle 26. The same axle also carries a one-armed lever, whose free end is provided with a roller which, at the proper moment, operates on an

irregular disc 29", when the one-armed lever is pressed downwards and the double lever with the bar 30 is pressed upwards

The pressure-piece 20, with the upper stamp, keeps pace with the lower cross-head 16, with the lower divided stamp 17, which is raised

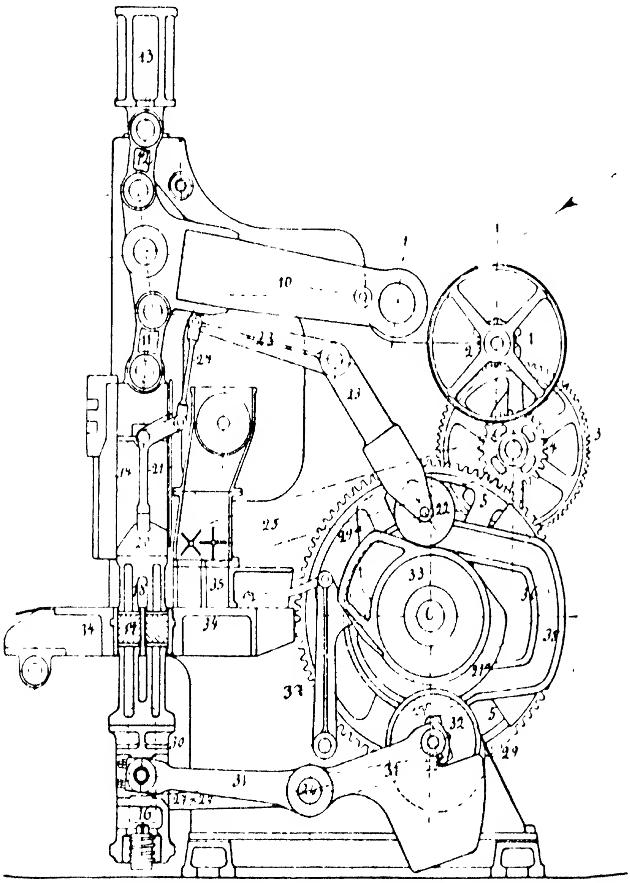


FIG. 72. Large Tigler toggle-joint press of modern type. Longitudinal section.

and lowered in a manner similar to the one previously described by the combined action of the lever 31, roller 32, and the irregular disc 33. In this way the briquettes resting on the lower stamps are lifted out of the moulds.

Advancing and Emptying the Charging Box into the Compression Moulds.—As soon as the discharged briquette is on a level with the mould table 34, the charging box 35 is moved forward by the curved

slide 36 and the roller and lever 37 and the briquette is pushed forward. At the moment when the charging box stands immediately above the compression mould 19, the cross-head 16, with the lower

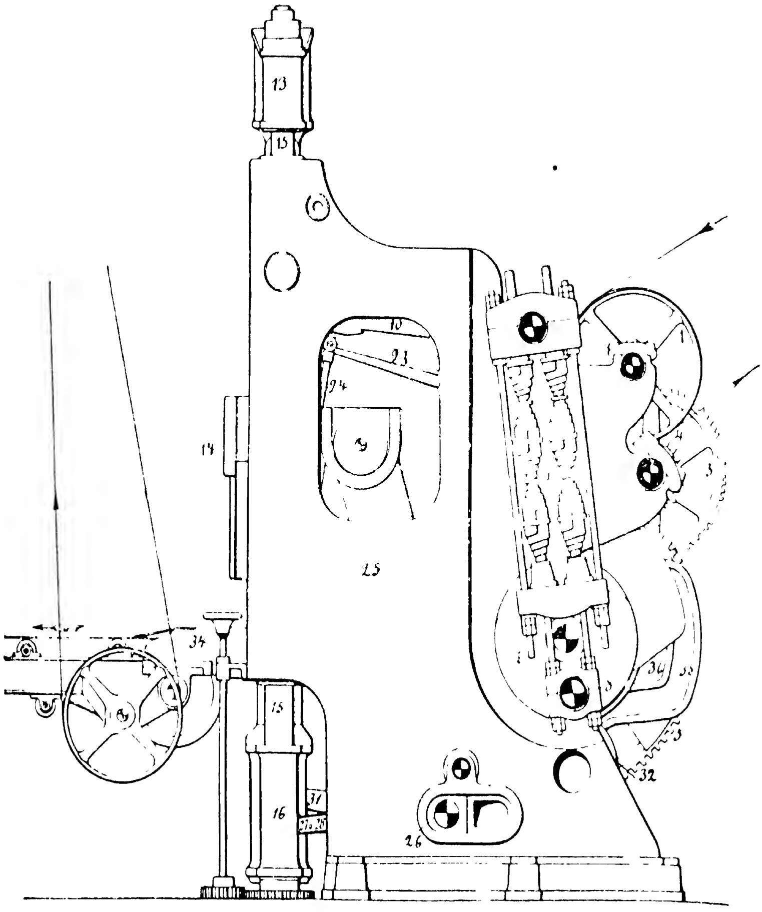


FIG. 73.—Large Tigler toggle-joint press, modern type. Side view.

stamp, are lowered, the mould chambers are again opened, so that the charging box can be discharged into them and the box again removed.

The curved slide 36 is therefore provided with a circular position of rest 38 for the roller of the lever 37, so that for a time the charging box remains at rest in its advanced position over the compression mould 19.

Further, the irregular disc 29", which operates the pressure member

20 with the upper stamp 18, has a hollow 39 on its circumference in which the attached roller 29 runs during the period of rest, causing the upper stamp to push the briquetting material from the charging box into the mould chamber.

Descent of the Upper Stamp and renewed Compression.—When the moulds are filled the irregular disc on the crank axle again acts on the system of levers and the pressure-piece 20 so that the upper stamp 18 is caused to fall into the compression mould with a striking velocity. Simultaneously the connecting bar 21 is forced back into its vertical position in a similar manner and the pressure of the toggle joint again takes place, and so on. During working the compression stamps are constantly cooled with cold water flowing through suitable channels.

Security.—The object of springing the connecting rods of the toggle-joint, which has been mentioned at the beginning, is to act as compensation for excess of pressure arising in the press, whether from excessive charging or from the introduction of foreign materials into the mould. As soon as a certain limiting maximum pressure is attained and at the beginning of the excess pressure, the connecting rods increase in length, and breakages are prevented.

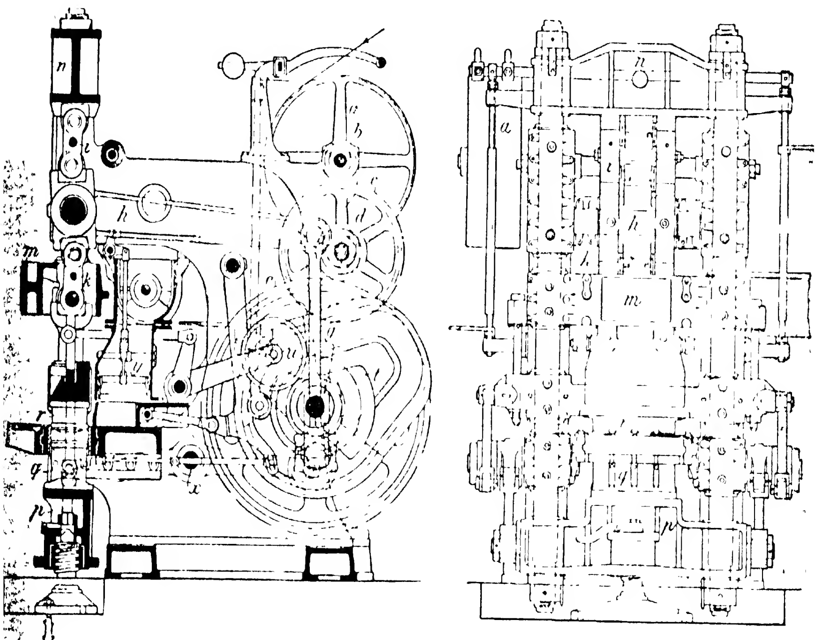
Moreover, one and the same Tigler press is applicable to various shapes of briquettes. It is only necessary to exchange the corresponding stamps and moulds, which is comparatively simple, and can be done without taking up too much time.

Two or three men are required to look after a Tigler press. One of them, the press overlooker, has to regulate the supply of briquetting material by means of the slide of the discharge opening of the steam stirrer and to put the press in and out of operation; he or the second man has to regulate the compression in the manner indicated above, and to test the briquettes for hardness, by hand.

This modern type of large Tigler press is constructed for the following sizes and outputs of briquettes:

Briquette Measurements	Briquette Weight.	No. of Briquettes per Compression	Output in 10 hours	Compressions per minute
mm.	kg.		tons.	
300 × 200 × 125	10	3	170–180	10
290 × 150 × 125	6	4	120–130	10
215 × 160 × 130	6	6	200–210	10
280 × 150 × 110	5	4	110–120	10
215 × 160 × 130	5	6	170–180	10
220 × 110 × 105	3	8	130–140	10

(C) *Small Tigler Press* (figs. 74 to 76).—A few years ago the Masch. Akt.-Ges. Tigler made toggle-joint presses for the production of small briquettes weighing from 1·1 to 0·2 kg., but at the present time they do not find much use as coal-briquette presses, and are only delivered singly and to meet special requirements. Recently, however, the firm has built such small presses as high-pressure machines for pressures of 500 to 800 atmospheres for the preparation of coal, coke,



Section. Front view

FIG. 74.—Small Tigler toggle-joint press.

and ore briquettes, preferably with cellulose pitch as bond. This point will be discussed later.

The small presses, although operating in a similar way to the presses for large briquettes, are built according to special requirements, and in comparison with the larger presses show, as will be seen from fig. 74, many minor alterations, but the only considerable difference lies in the charging appliances for the charging box.

On account of the small compression moulds it has proved to be necessary to introduce the material falling from the worm conveyor into the charging hopper *y* into the small openings of the charging box by force. This is effected by a system of slides built in the

charging hopper. The slides can be moved horizontally, are set in motion by an eccentric, and rake the surface of the charging box several times.

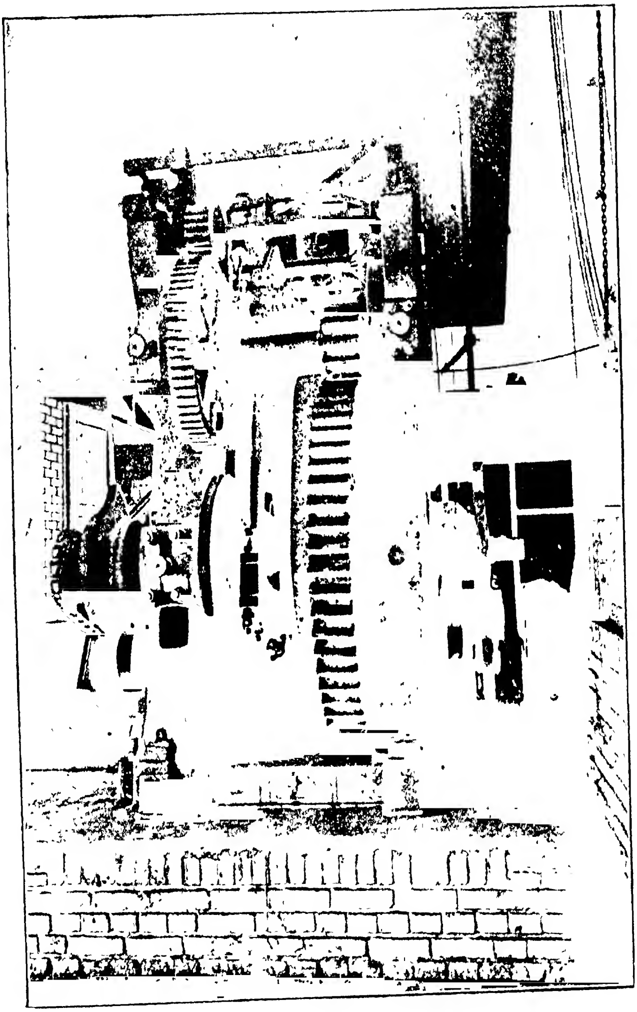


FIG. 75.—Small Tigler press. Back view.

For cooling the stamps, which become very hot because of the continual friction with the sides of the small moulds, channels are bored in the stamps and cold water circulated through them continually.

Figs. 75 and 76 show the back and side views of a Tigler press f

small briquettes. The latter view shows the opening at the end of the worm conveyor with a falling chute built in front. This serves as an

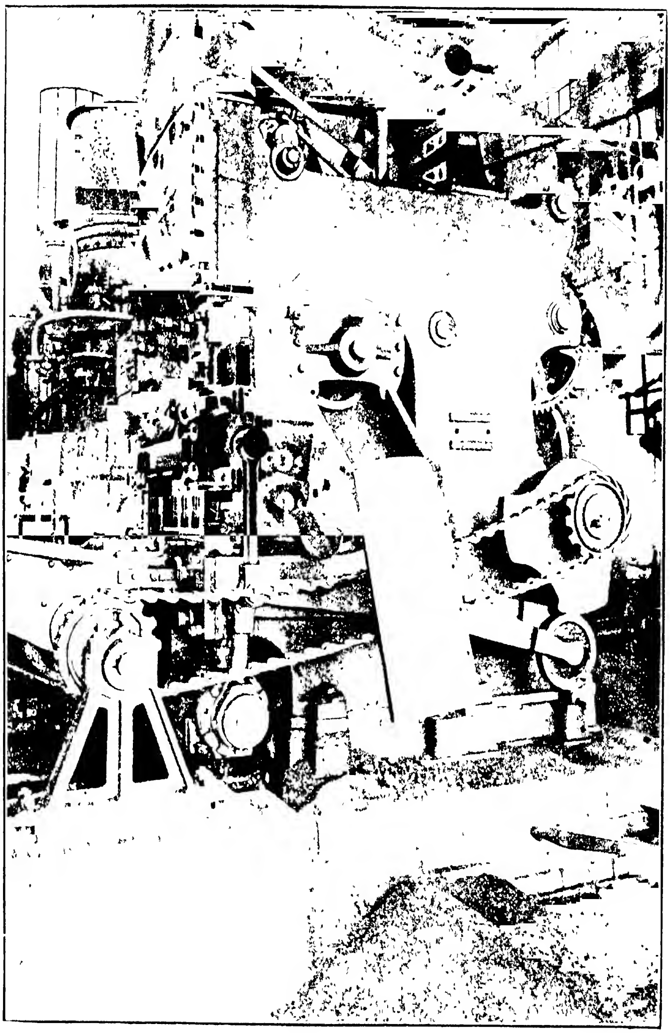


FIG. 76.—Small Tigler press. Side view

overflow in cases when the whole of the briquetting material supplied does not pass through the charging hopper and box for compression. The charging appliance of the filling box is also provided with a similar overflow (also seen in illustration) for the same purpose. The

Gall chain in the foreground drives the roller attached to the press for the motion of the endless loading band on which the discharged briquettes are carried away for shipment

OUTPUTS OF THE SMALL TIGLER PRESSES

Briquette Weight	No. of Briquettes per Compression	Output per 10 hours.	Compressions per minute
		tons	
1·1 kg	9	40–50	10
125 grm	16	30–35	10
150 ,,	18	35–40	10
215 ,,	32	30–35	10
85 ,,	18	20–25	10

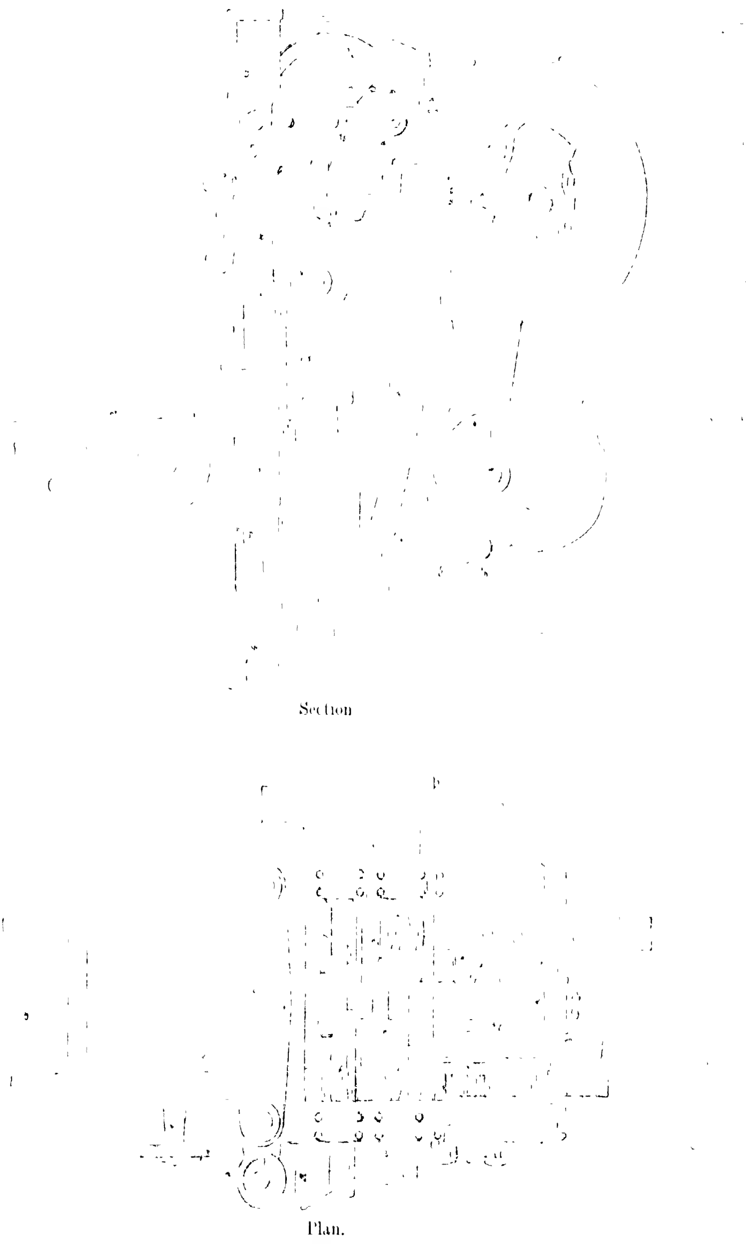
Toggle-joint Lever Press Schuring's Patent (figs. 77 and 78) This new press is constructed by the Zeitzer Eisengiesserei und Maschinenbau Aktiengesellschaft, and for some purposes is preferred to the revolver presses also constructed by this firm (Yeadon Busse, etc., see above) Generally their design is similar to the Tigler design, but in detail there are considerable differences especially with regard to the charging of the filling box and the motion of the links of the toggle joint and so forth The drive is obtained by means of a belt pulley *a* and the double helical gear-wheels *b*, *c*, *d*, *e*, which set the crank axle *f* revolving This serves as the main shaft for the operation of the various appliances described individually on p. 158 above.

1. *Filling the charging box.* The briquetting material is conveyed from the familiar steam kneader by the worm R Between the worm and the charging box L is a charging appliance S (protected by patent) which ensures a uniform distribution of the mass

2 The advance of the full charging box L is effected by the link K through the lever J, roller H and the curved slide G which, keyed on to the shaft *w*, correspondingly moves the roller H etc., running upon it by its rotation. The shaft *w* is driven from the shaft *f* by means of the gear-wheels *z*, *y*, and *x* By the preliminary movement of the charging box over the compression moulds, the discharged briquette is pushed forward at the same time until it falls on to a conveyor band N

3. The opening of the moulds is caused by the rapid descent of the lower stamp E and press head D, effected by the motion of the roller B on the cam disc A revolved by the shaft *w*

4. At the same time, the briquetting material is pushed down into the mould from the charging box by the upper stamp *c*, which, with its press-



Section

Plan.

FIG. 77. Schuring patent toggle-joint lever press

head u, is rapidly lifted and lowered by the alternate short stretching and bending of the toggle-joint links s and r by means of the bar h and the lever o, since the latter has communicated to it at this moment a rapid to-and-fro motion from the cam m keyed on to the crank axle l

5 If the upper stamp r has again assumed its highest position the empty charging box L is again drawn back by the curved slide G

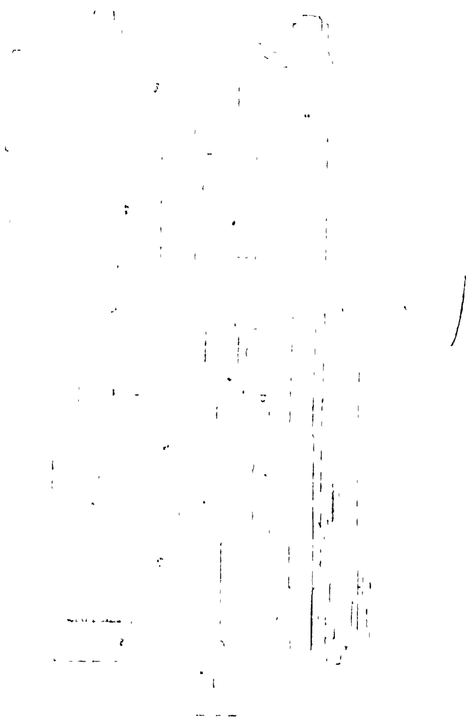


FIG. 78 Scharing patent toggle-joint press Front view and section

Then the cam m causes the lever o to return suddenly, the upper stamp r falls on to the material to be pressed with a blow and gives rise to a preliminary compression

The rapid falling away of the cam m is effected in such a manner that the roller n does not run on the re entrant edges of the ring, but on a nose O, situated on the lever o, which mounts a specially provided annular surface and keeps the roller swinging over the hollow until the outer edge of the roller has passed the corner of the ring, as soon as the middle of the roller has reached the corners. At this point the end of the nose has only reached the corners of the ring and slides off the inclined surface. By means of this appliance a very rapid falling motion of the upper stamp is obtained. Further,

during the revolution of a handle time is gained for the double angle of fall of the roller *n*, which, added to the functions of the other cams and curves, permits of a larger and steadier rising angle on the roller, and in this way increases the number of strokes and the output of the press.

6. The principal compression now completes itself as in the Tigler press, by the stretching out of the links *r* and *s* of the toggle-joint lever in such a manner that the upper press-head *u* and stamp *v* are pressed into the mould. Simultaneously, the lower press-head D with the stamp E are forced up, the force of the toggle joint, which is really applied above, being transmitted, by means of the upper cross-head P and the tie-rods Q at both sides, to the lower cross-head D. It has already been indicated that the straightening of the toggle-joint is effected by pushing forward the tension bar of the crank axle *f*. The tension bar consists mainly of three interdependent parts: the part *g*, with the connecting head and screwed cross-head with the back guiding bar, secondly of the part *h* which is forked so as to act as a guide for the part *g*, and, thirdly, of the bolt *i*, which is situated in the cross-head and presses against the back portion of *h*. During pressing the three parts form a rigid whole.

7. The subsequent lifting of the upper stamp is effected by the bending of the knee lever. After the resulting compression the bars *i* are released by means of projections *l* attached to the crank webs and fixed in this position. The parts *g* and *h* can now perform various movements. While the crank axle *f* with the portion *g* steadily advances, the cam *m*, situated on the same shaft, lies against the roller *n*, which is situated at one side of the fork-shaped lever *o* enclosing the tension bar. The lever *o* is again connected with the tension bar by means of the link bar *p* and the intermediate regulating and stopping appliance. Therefore, after the bars *i* are released the tension bar is rapidly moved backwards by means of the cam *m*, the roller *n*, the lever *o*, and the link bars *p*, on further revolution of the crank shaft. In this way the toggle-joint links *r* and *s* are bent, the triangular guide *t* is brought into the swinging position, and the upper press-head *u* with the press-stamp *v* rapidly lifted.

The simultaneous elevation of the lower stamp E pushing the prepared briquette up to the upper edge of the press table F is completed by the two-armed lever C, whose right arm is depressed at this moment by means of the cam A acting on the roller B, so that the left arm with the lower cross-head D resting upon it and the lower press stamp E must be elevated to a corresponding extent.

After these various operations the advance of the charging box etc., again takes place as already described.

Balancing the Weight.—In order that the weights of the parts *a*, *c*, D, P, Q, etc., shall not affect the initial upper compression to the detriment of the lower compression and give rise to an irregular displacement of material, a spiral spring T is provided and put under a tension sufficient to balance the weights.

For security against breakages under heavy loads, the front tie rod head is provided with a changeable disconnecting appliance. It acts in such a manner that when the pressure is exceeded by 75 to 100 per cent. the stamp U presses through the disc V made of soft steel and the press runs steadily again. Changing the table can be accomplished in about ten minutes.

Regulation of the Charging and Pressure.—The charging of the mould is regulated by a nut and screw W, attached to the lower cross head; the pressure, however, is fixed from the press attendant's stand by means of the hand wheel X, tooth wheel Y, and the chain wheel with the chain Z.

In order to maintain the maximum pressure constant for a certain angle of revolution at the extreme position of the crank and stretched position of toggle joint links a bolt with a roller I is fixed at the side of the tension bar *h*. This lies on a segment of a ring II, and fixes *h* until the bolt *i* is disconnected.

The presses are very powerfully built throughout. All the moving parts run in large bearings provided with good lubrication arrangements. Special attention is paid to the ease of renewability of all parts. Schuring patent toggle-joint presses are constructed by the Zeitzer Eisengieszerei und Maschinenbau Aktiengesellschaft in two sizes, with the following outputs:

Model I				Model II			
No.	Weight	Measurements of Briquettes	Output in 10 hours	No.	Weight	Measurements of Briquettes	Output in 10 hours.
	kg	mm	tons		kg	mm	tons
1	2	170 × 100 × 95	110	1	11	330 × 210 × 135	210
2	1.2	160 × 80 × 80	95	2	10	330 × 200 × 130	190
3	1.0	160 × 85 × 65	75	3	5	235 × 159 × 125	190
4	0.150	160 × 55 × 50	50	4	3	220 × 110 × 105	170
5	0.225	60 × 60 × 55	55	5	2	175 × 105 × 100	150
				6	2	290 × 190 × 90	130
				7	1.2	160 × 80 × 80	120
				8	1	160 × 80 × 65	110

Sutcliffe Toggle-joint Press.—This new press, called "The Emperor," built by the firm of Sutcliffe, Speakman & Co., at Leigh in Lancashire (England), differs from the previously described toggle-joint presses principally in that the briquettes are compressed in simple or double moulds on a round revolving table, which is held fast and pushed round similarly to the Couffinhal, Veillon, and other systems. The Sutcliffe presses, although suitable and utilised for coal briquetting, are, however, extensively used for the production of lime sandstones, artificial stones, ore briquettes and the like, and find application in and out of England and also in Germany. Its description and illustration therefore will be given in Part III. of this work.

Tests and Scope of the Toggle-joint Press.—The newer toggle-joint press recommends itself specially in that at every stroke of the press a certain number—three to eight large or a corresponding larger number of small briquettes—are produced, as a result of which increased outputs can be obtained, and, further, that the previously described weights of the briquettes can be accurately checked by regulating the charging. For example, briquettes from 30 to 85 mm. can be obtained from Model I of the Schuring press, and from 60 to 135 mm in height from Model II. without necessitating the changing of any of the parts of the press.

In other respects the toggle-joint presses, as is the case with all presses with horizontal mould tables, are considerably less suitable for small briquettes (below 3 to 2 kg.) than for large briquettes. In the case of a Tigler press in Lower Silesia turning out short columnar 1-kg briquettes, two men are required solely for laying the briquettes on the conveyor band in addition to the press overlooker. This means costly additional labour which is not required in the revolver press, and is equally unnecessary for toggle-joint presses making large brick-shaped briquettes. From this and other causes the Masch. Akt.-Ges. Tigler has recently decided to discontinue the construction of small presses for coal briquetting.

As a result of the relatively small number of compressions per minute (about 10), the operation proceeds steadily with a gradually increasing pressure, and the final pressure persists for some time, especially in the Schuring system. The briquettes can therefore be thoroughly compressed and a uniform high strength obtained on all sides with the least possible addition of binding material.

Such favourable experiences have not been obtained at a briquette factory in Lower Silesia, equipped with a Tigler press of the old type.[1]

[1] According to the account of the works directors.

The briquettes prepared by it are not so uniform nor so tenacious as those prepared in a Zeitz revolver press working close by (Yeadon Busse).

With regard to the necessity for repairs, the toggle-joint press at the latter works shows up equally unfavourably compared with the Zeitzer press. From another source, however, the reverse is asserted, that the repair costs are considerably higher in the case of the revolver presses.

In any case, the construction of one or the other system of toggle-joint presses is not simpler, the number of moving parts is scarcely less, however, the toggle-joint press has the good property, which is not to be depreciated, of having all the working parts easily renewable, as well as the conveyance of briquetting material and charging of the press chambers visible, and consequently under the control of the press attendant

It is of special importance to have a thoroughly reliable forward and return motion of the charging box, so that the divided upper stamp does not knock against it, otherwise great damage is easily done

The relation between price and output of the revolver and Schuring patent toggle-joint press is roughly as follows :[1]

	Price.	Hourly Output.
	M	tons
Model I. Revolver press, inclusive of steam kneaders . .	15,000	4 5.5
Model II. " " " " . .	18,000	6 8
Model I. Schuring toggle-joint press, including steam kneader and worm conveyor	21,000	5-11
Model II Schuring toggle-joint press, including steam kneader and worm conveyor	27,000	10 21

It appears to be advantageous to select toggle-joint presses for large outputs in spite of the higher prices, because the costs for attendance and buildings are much lower. The superintendence of toggle-joint presses of course requires close and continual attention, which necessity increases with smaller briquettes and the number of stamps in operation. Consequently, the machine must not be left unattended even for a short time during working, otherwise there is considerable risk of breakages or strains to various parts of the press (especially in

[1] According to the account of the Zeitzer Eisengiesserei und Maschinenbau Akt.-Ges., spring 1908.

the older type), caused, for example, by the adherence of the pressed material to the lower stamp which falls automatically after each compression because of its weight.[1]

The toggle-joint presses are in any case superior to the old-established Couffinhal presses with regard to simplicity and accessibility in construction and attendance, certainty in operation, and lower necessity for repairs. In spite of the possibility of higher output, the toggle-joint presses have not been largely introduced into Lower Rhenish Westphalia, where the Couffinhal presses have held the field for a long time: at the end of 1907 only 6 toggle-joint presses (Tigler) were in operation against 143 Couffinhal presses, although in this district by far the greater proportion of the briquettes produced are of 3 kg. weight and above.

However, special attention must be called to the fact that the toggle-joint presses are still only at the beginning of their development, that they have already been considerably improved from the original imperfect designs, and that they may be still further perfected as a result of further experiences in working.

Class III. Briquette Presses with Tangential Action.

1. Presses in which one Briquette is formed against the back of another (Rope or Sausage Presses). The principle of these machines depends on the plastic briquetting material being pressed into an elongated channel, which is open at both ends, by a pressure stamp which is moved to and fro. On the return movement of the stamp a certain amount of material falls into the mould, while during the forward motion the stamp compresses the material against the previously compressed mass and pushes the whole briquette rope further along the mould. In this way the front end emerges from the mould, where it is cut into a number of briquettes corresponding to the strokes of the stamp with the aid of automatic arrangements or knives. During the compression the principal resistance to the stamp arises from the friction between the mass to be compressed, the briquette rope, and the walls of the mould. This friction is very great, and increases with the length of the mould channel. According to Evrard, a drilled and polished cast-iron tube 8 cm. diameter, with a 3-cm. wall, bursts when a column of coal slack 35 to 40 cm. long is driven into it.[2] It is quite

[1] *Niederrhein Westfal. Sammelwerk*, vol. ix., 1905, p. 660.
[2] Preissig, 1887, p. 145.

clear that machines with open moulds require a far greater amount of pressure than presses with closed moulds, to produce the same degree of compression

The nature of the mixture, together with possible irregularities in the supply, cause the friction to vary within very wide limits. In order to compensate for this defect and to attain as constant a pressure as possible, the rope press has been provided with appliances which allow of the regulation of the pressure at which the rope issues from the mould.

Since the briquettes are not pressed into finished blocks, but are obtained only after cutting the emerging briquette rope, their appearance, especially with the larger shapes, leaves much to be desired They often exhibit rough cut surfaces and crumbled corners, in addition to which there is a corresponding large waste

Of the machines belonging to this class, only those of Evrard and Bouriez find much application Originally, small cylindrical (fig 4, Nos 5 and 6), and later cubical, briquettes were prepared in France (La Chazotte etc) by the Evrard press, which has now become obsolete, while large coal bricks are produced by the Bouriez press, which still finds considerable use especially in Belgium

Bouriez Rope Press (figs. 79 and 80) The Bouriez press has one or two, and occasionally three, horizontal channel moulds situated next to each other Their section is rectangular with rounded corners, usually measuring about 216 × 152 mm., while the length amounts to 1·66 metres. They consist of two parts the lower half is fixed to the frame of the machine, while the upper half is pressed down by means of a loaded lever (fig 79) or by means of a screw press with springs (fig 80). The channel mould receives the material to be compressed from a common steam mixer and several distributing boxes with a whirling shaft, whose further end leads to the charging opening *o* (fig 79) The compression stamps have 300-mm strokes, and are driven by two cranks on the shaft *w*, which is connected with the axle *a* by a gear drive and revolves at the rate of 22 revolutions per minute At each stroke of the stamp a brick 157 mm. (6 in.) thick is made against the back of the previous one, and at the same time the whole briquette rope is pushed forward 6 inches. The rope emerging from the mould is taken up by a band conveyor mounted on rollers. Each brick adhering to one prepared after it can easily be detached by the aid of a knife at the contact surface

In the twin-rope press Guinotte has provided a hydraulic com-

pensator H R (fig. 79) for regulating the action of compression. At the back both stamps end in plungers, whose two cylinders are immediately connected. In the communication tube a vertical tube is fitted, closed by a piston H provided below with an elongated guide rod and the necessary bushes.

Output.—At 22 revolutions per minute of the crank shaft a twin machine delivers 44 briquettes, each of about 4·1 kg., or a total of 150 tons in a 12-hour shift (125 tons in 10 hours). By cutting off briquettes of double length, large blocks of twice the weight can be produced.

The Bouriez presses are distinguished by great simplicity and by the fact that they can be applied to very moist coals. On this account they find a good deal of use, especially in Belgium and the north of France. With them unwashed or washed coals almost wholly undried

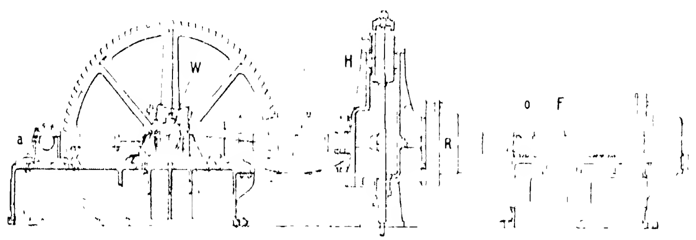


Fig. 79. Bouriez "rope" press with hydraulic balance. Longitudinal section.

and usually containing 8 to 14 per cent. water, are worked up, but a much higher addition of pitch (8 to 9 per cent.) must be made. Other disadvantages are that greater power is required, the moulds need frequent renewal even after four to six weeks' use with certain coals; further, the briquettes are smooth only on four sides, corresponding to the walls of the channel, but the cut surfaces are more or less rough and are occasionally irregular.

In Germany, especially Rhenish Westphalia, only few presses of this system have been used (at the Guszstahlwerk von Friedrich Krupp, Essen, the Zechen Franziska Tiefbau, Blankenburg, and Wiesche), and these were abandoned in the 'nineties. The briquettes prepared by them did not find much favour with the buyers. In order to bring them into the market they must be offered at 5 to 8 marks per double load (10 tons) cheaper than the ruling market price of the products of the Couffinhal presses.

2. Machines which produce the Compression by a Pair of Rolls

(Roll Presses) Egg-Roller Presses—These presses work on the lines of a roll crusher with two horizontal rollers rotating in opposite directions In the surfaces of the two rolls which almost touch each other, are numerous corresponding half moulds of the shape of a flat semi ellipsoid arranged in series The soft briquette mass is conveyed to

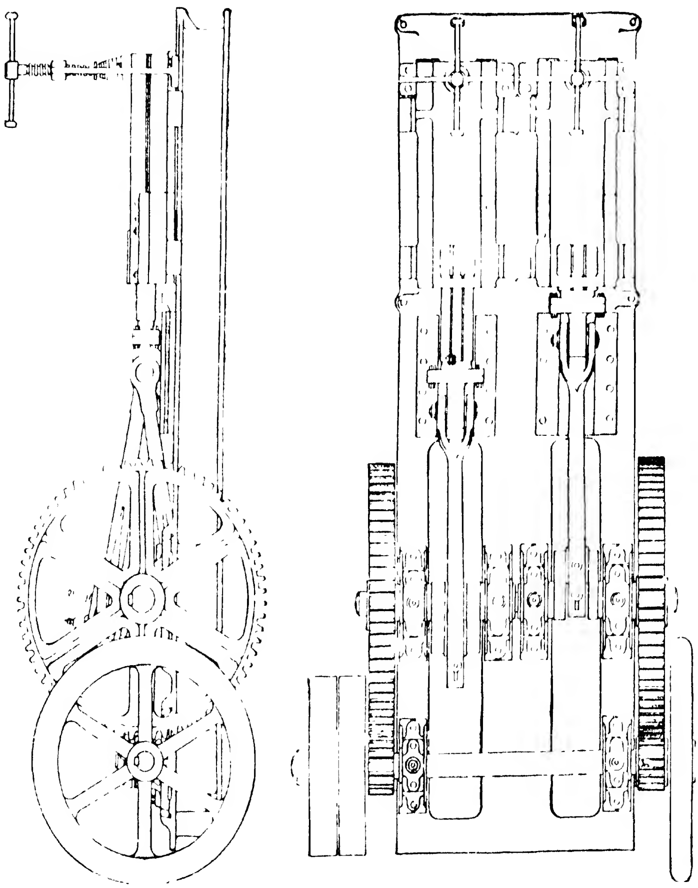


FIG. 0.—Bourriez twin-rope press. Longitudinal section and plan

the moulds from a distributor arranged over the middle of the press, and during the slow rotation of the rolls is compressed to briquettes, somewhat resembling eggs in shape. The pressure gradually increases (up to 50 kg. per sq cm) during the gradual closing up of the mould. On further rotation the briquettes fall out of the moulds as the two rolls separate from each other

Fig. 5 (p. 8) shows, under Nos 9 and 10, a few, fig. 7 (p 11)

shows a larger number of such egg briquettes of the size of a lens-shaped flattened goose egg down to that of a pigeon's egg. Their origin is clearly indicated by the rough edge rolling seam—which projects from most of them.

With regard to the application of these briquettes, see p 9 and p. 12.

The moulds are situated in the renewable hard cast-iron or steel jacket of the rolls They are exposed to considerable wear, and suffer especially because it not infrequently happens that the finished briquettes adhere to the moulds, and on the further rotation of the rolls again arrive at the compression zone with fresh material, which naturally leads to interruptions in the working.

To facilitate the loosening of the "egg," warm water is circulated in the interior of the rolls at the beginning of the operation and afterwards replaced by cold water This, however, does not always have the desired effect

Usually the eggs fall first on to a smooth slide, whence by rolling or sliding, or by the aid of a band conveyor, they are led to the railway waggons or other loading arrangements (sacks for oversea transport, see p 10)

Since during the revolution of the rolls against each other the whole of the briquette material supplied cannot be forced into and compressed in the moulds, there is considerable waste, which is increased by the material left adhering to the moulds and the briquettes broken and crushed by repeated compression This total waste usually amounts to between 4 and 10 per cent., according to the arrangements and the ruling state of the rolls, etc. It is usually returned to the distributor

The first egg-briquette press used was that of Loiseau, it was put into manufacturing operation towards the end of the 'seventies in the briquette factory organised by him at Port Richmond in North America. On the continent of Europe the similarly constructed machines of Fouquemberg, Zimmermann & Hanrez, Schuchtermann & Kremer, and others have been preferred. In Germany only the two latter systems have been introduced.

Egg-Roll Presses of Schuchtermann & Kremer (figs. 81 and 82).—The distributor V, fitted with a stirring shaft and wings, causes the briquette mass to fall through two radial openings in the bottom and the corresponding hopper t, between the two mould rolls $f f_1$, which rotate in opposite directions on the shafts $w w_1$.

This is effected by the wide, powerful gear-wheels Z, which are

keyed on to the centre of the shafts and engage with each other exactly. It is only necessary therefore to drive one shaft from the

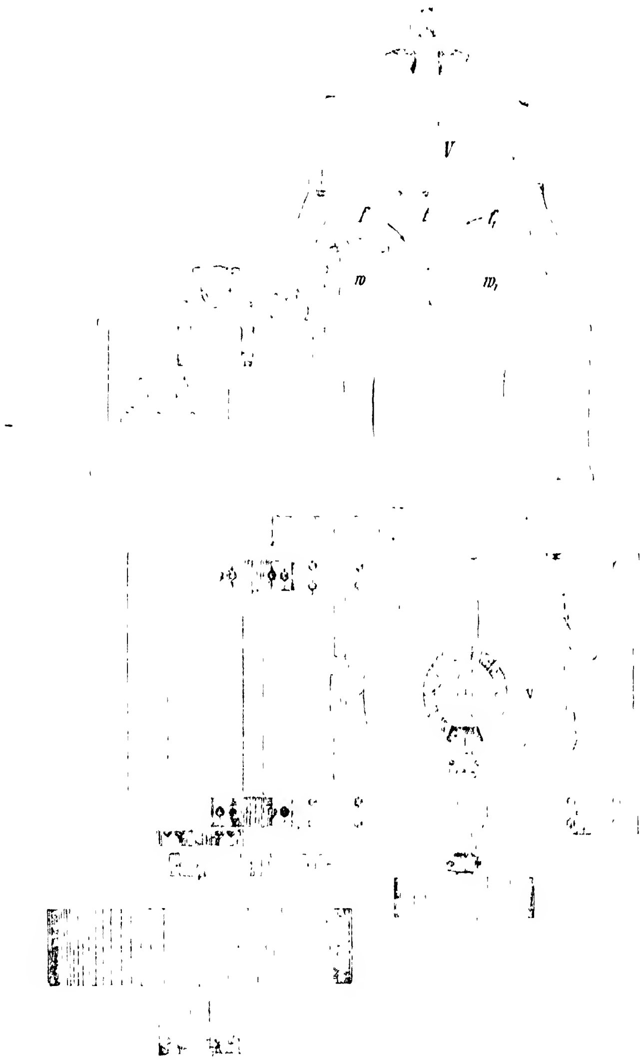


FIG. 81.—Schuchtermann & Kremer's egg-roll press. Longitudinal section and plan.

belt pulley *s* by means of a spur-wheel. As a result of the break in the centre to admit the gear-wheel Z, each roll is in two parts, *i.e.* made up of two separated equal-sized rolls. Their surfaces are utilised for the compressions as much as possible in that the moulds are arranged

in horizontal, alternate series arranged close to and above one another The longitudinal axes of the moulds are situated in the direction of rotation The individual horizontal series have alternately four moulds of equal size, and three such moulds in the middle and two half-sized moulds at the sides Consequently, the pair of rolls always compress and deliver eight whole, or six whole and four half, egg briquettes at a time.

Zimmermann & Hanrez Egg-Roll Press (fig 83). The egg-roll

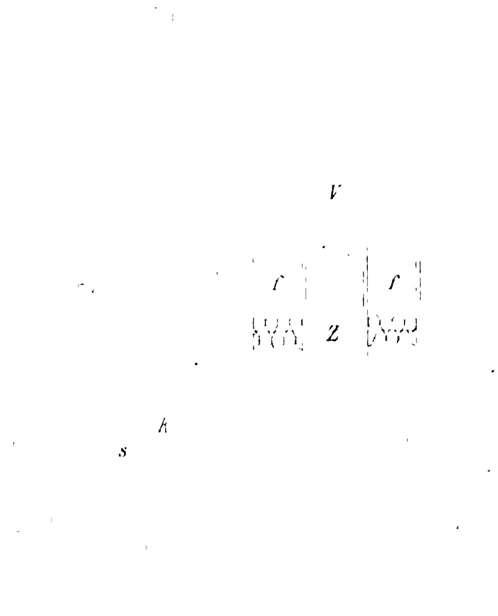


FIG. 82.—Schüchtermann & Kremer egg-roll press. Side view

press (Boulet press) of Zimmermann & Hanrez,[1] Monteeau-sur-Sambre, exhibits a different formation of the roll surface, but is otherwise of quite similar construction A horizontal series of three large moulds alternates with a series consisting of two large inner and two small outer moulds, the large moulds have their main axes parallel to the shaft, while those of the small moulds are at right angles to the shaft. At each compression therefore six large or four large and four small briquettes are obtained alternately.

Egg- or Ball-Roll Presses in North America.—At first the Belgian presses of Loiseau and others were applied, but very shortly the con-

[1] *Sammelwerke*, vol. ix. p. 635, fig. 300.

struction of machine presses suitable to the local needs was undertaken as soon as it became evident that the production of small egg or ball shaped coal briquettes fulfilled the requirements of the American coal markets at all events far better than the large rectangular shapes preferred in Europe. Consequently there opened out in America prospects of wider application for presses of the above description, especially for those showing the possibility of large outputs.

The first American ball press applied on a manufacturing scale was

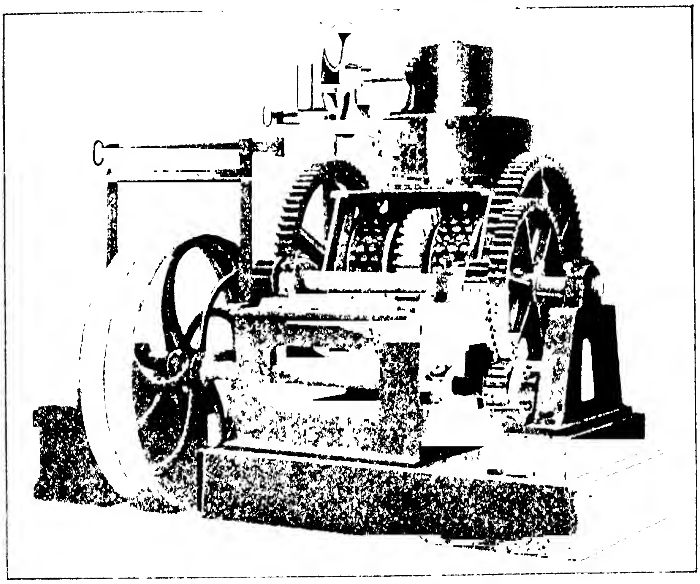


FIG. 83. Egg roll press. Zimmermann & Hanrez.

constructed by G. J. Mashek,[1] who combined later with the Traylor Engineering Co. of New York. It is described and illustrated in the publications given below, and consists principally of a pair of rolls whose surfaces are as close as possible, diminishing the unused interspace to a minimum, and are covered with series of hemispherical moulds producing pill shaped briquettes weighing 1 to 3 oz. (28.3 to 85 grm.) for domestic fuels. Most of the users prefer 2-oz. briquettes (56.7 grm.) corresponding to the size of anthracite nuts. Naturally the weight is largely determined by the nature of the dust from which the briquettes are prepared. For briquettes from coke smalls a weight of 2.5 oz.

[1] *Iron Age*, vol. lxxvii., 1906, pp. 1330-1333, and *Bi-monthly Bulletin of the American Inst. of Mining Engineers*, 1907, p. 799.

(70·9 grm.), for briquettes from soft coal and lignite a weight of 3 oz. (85 grms.) is most desired. The mould cylinders are renewable, and about two hours is taken up in changing them.

The Traylor Engineering Co. of New York has recently built a Mashek press for E. B Arnold, West 47th Street, New York, the output of which amounts to approximately 14 tons per hour, but on account of special local circumstances it can only be used up to about 10 tons

SECTION VIII

LOADING AND STORAGE OF BRIQUETTES. POWER EQUIPMENT AND MANAGEMENT OF BRIQUETTE FACTORIES.

A. LOADING OF BRIQUETTES.

THE conveyance of the compressed and discharged briquettes from the presses to the railway waggons, etc is effected by means of bands and chutes

In the case of Schuchtermann & Kremer's Coulfinhal presses producing the ordinary 3-kg briquettes, these are generally arranged as follows The endless transport band, which is set in motion by a bevel drive and two rollers of about 500 mm diameter consists of a network of wire 250 mm broad and 5 metres long stretched in a horizontal plane by three upper and two lower rollers The briquettes are led to the band by a sheet-iron chute as they are pushed out of the Coulfinhal press one after the other, so that their long axes lie in that of the band (see fig. 87, p 193). This conveyor carries the briquettes over the loading stage of the briquette factory to the lower chute, down which they slide into the railway waggons

Both chutes are inclined at about 45 down to the lower end, which is bent upwards with a radius of 1300 mm. in order to correspondingly diminish the velocity of the sliding briquettes before they are taken from the mouth of the chute by the loaders who stand in the waggons. The lower chute is built up of several parts The front part hangs on two chairs, the upper part, at the roof of the loading stage, is led over two rollers, and the back overhanging edge is loaded by weights to balance the weight of the chute. In this way the chute can easily be raised or lowered according to requirements

The wire-netting bands intended for conveying larger briquettes, each of 5 kg weight and above (up to about 11 kg), are correspondingly broader, particularly when four or still more blocks are produced

and delivered at one compression by means of toggle-joint presses. The same applies to the simultaneous production of a large number of

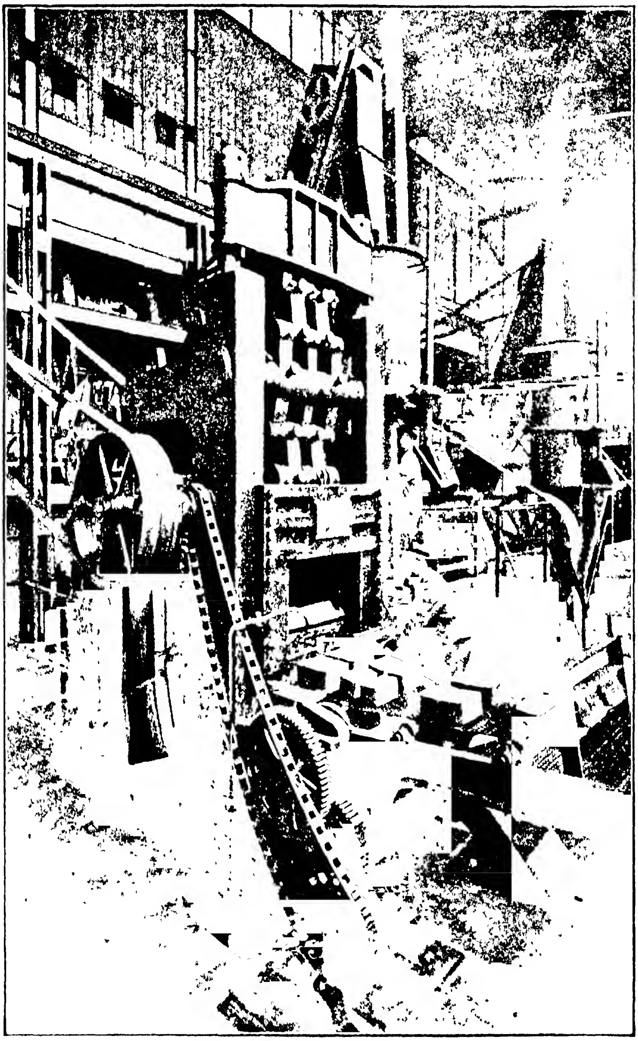


FIG. 84.—Transport band for large briquettes from a Tigler press with scraping arrangement

small blocks by means of a revolver, but more particularly by toggle-joint presses. For the latter, conveyor bands up to about 1200 mm. in breadth find application (fig. 85).

Fig. 84 shows a band conveyor in front of a large Tigler press

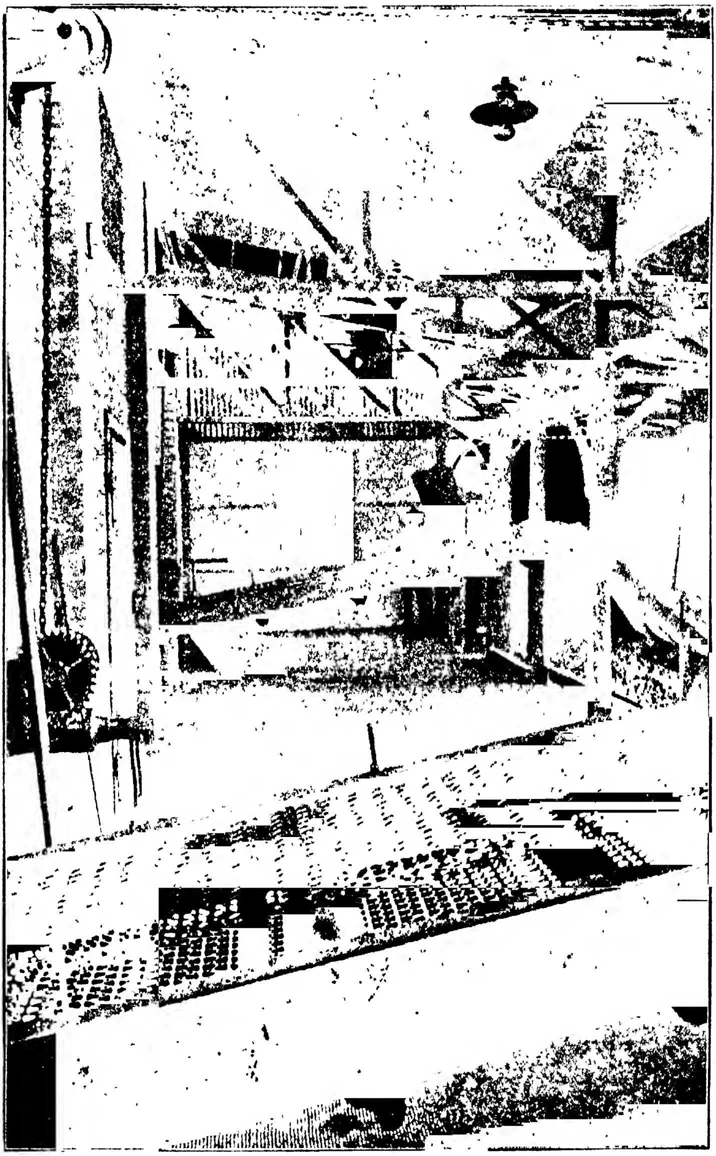


FIG. 85. Transport bands and chutes for small briquettes from Tigler presses (Rheinau briquette works).

which pushes on to it four large briquettes in a cross series after every compression. The band is set in motion by means of a Gall chain and toothed wheels from the main shaft of the press At the right is a scraper arrangement with movable cross bars, to which are fastened stiff square leather discs whose lower edges clean away the outstanding edges and other waste from the briquettes travelling below The leather discs soon get their edges turned up and then act badly, they must therefore be turned or recut very often. Probably sheet-metal discs or wire brushes would act much more efficiently.

During their motion on the transport bands, the briquettes, which are delivered more or less hot, cool down somewhat This is greatly to be desired, since the blocks only attain the necessary strength and rigidity by cooling when the bond hardens For this purpose the cool seasons are naturally more favourable than a hot summer The New Jersey Briquetting Co, Brooklyn, New York,[1] use for the cooling of heated egg briquettes three steel plate-conveyors arranged under each other and travelling in opposite directions, and on which the briquettes travel a total distance of 504 feet (about 168 metres) before they are shot into the storage bins or loaded into the waggons

Since the large briquettes must be cared for as much as possible during loading, they are carefully stacked one by one against and next to each other in rank and file in the railway waggons (see Plate II). According as large blocks in small number, or a larger number of smaller blocks are prepared, three or four attendants (usually young workers loading boys) are required to remove and stack the briquettes produced by one press. However, small cubical and egg briquettes do not require this. They are allowed to slide directly into the waggons, ships, etc, from the band conveyors over divided loading chutes, as will be seen from figs. 85 and 86. The loader has only to take care that the waggon is filled uniformly and is pushed forward in accordance with this object In addition, he has to effect the raising and lowering of the chute.

The waggon on the extreme right of fig. 86 is quite fully loaded with cubical briquettes, and has been pushed aside.

With regard to the loading of egg briquettes in sacks for oversea transport, enough has already been said.

Weighing the loaded waggons is most conveniently effected at the loading stage during the loading by means of an automatic arrangement

[1] *Bi-monthly Bulletin of the American Inst. of Mining Engineers*, 1907, p. 796.

which is arranged on the loading line in front of each conveyor. As soon as the scale indicates the necessary weight, loading is ceased. In

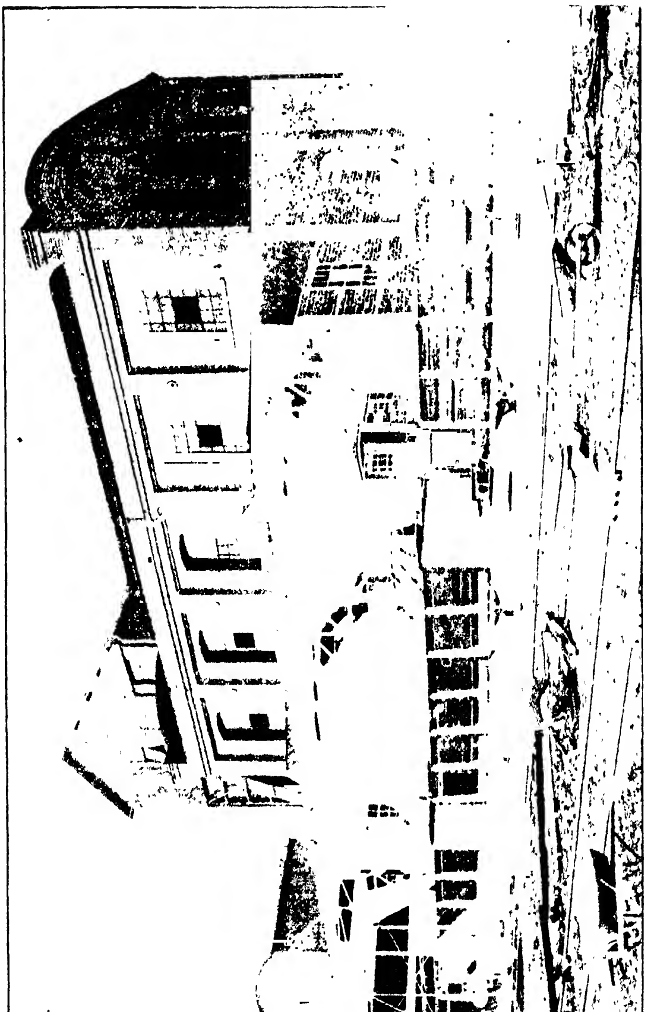


FIG. 86.—Loading small briquettes at the Brikettwerk. Rh..nau

this way time and expense are saved by obviating the use of other arrangements for the purpose of weighing and for possible unloading of excess or loading up too small quantities of briquettes.

B. STORAGE OF BRIQUETTES.

In cases of an insufficient sale for briquettes or a deficiency in the number of waggons, it becomes necessary to store briquettes so as not to interfere with the running of the briquette factory. Storage is not to be desired except in the case when it is necessary to effect a certain amount of after-drying by evaporation of water from briquettes produced from moist undried coal, because it introduces special storage costs since the briquettes must be transported to the store, and, with the exception of egg and cubical briquettes, have to be stacked by hand in regular heaps or rows. The expenses of loading therefore are extremely high. In addition the briquettes always suffer and lose their good appearance more or less, under the carrying to and fro and storing by the crumbling of sharp edges.

With the object of keeping the costs of storing and loading as low as possible and to prevent depreciation in value, it is recommended that the conveyance of freshly pressed briquettes to the store which should obviously have as favourable a situation as possible, as well as the subsequent carriage of the blocks from the store to the railway waggons, is best effected by band conveyors similar to the loading bands already described.

This is carried out in quite a reliable manner at the Glückauf shaft of the Freiherrlich von Burgker Steinkohlenwerke in Potschappel, Saxony, for example. A band conveyor running the whole length of the loading track takes—when loading into waggons cannot take place immediately—the briquettes coming from the press and carries them partly to a light roofed storage place situated close to the factory, and a second band conveyor which stretches across the whole place at right angles to the first conveyor. Both ends of the frame rest on rails by means of small wheels very much in the manner of a travelling crane, and by this means it can be moved backwards and forwards as required. In this way the briquettes can be conveyed mechanically exactly to the spot where they have to be stored in rows parallel to the conveyor. Here they are taken from the band by hand and laid down. If later they should have to be loaded on the railway, the loading is effected by the same band conveyors, which are then caused to run in the opposite direction. The bands are driven electrically. The whole arrangement has proved very efficient.

C. POWER EQUIPMENT, OPERATION, AND MANAGEMENT OF BRIQUETTE FACTORIES.

The power equipment of a briquette works attached to the screening or washing plant of a colliery is obtained from the ordinary boiler plant, etc., or the central electric station, according as the plant is driven by steam engines or electric motors. In recent times the latter method finds increasing application on the well known technical and economic grounds. It is also being applied in older factories. Remotely situated briquette works require at the most a special small steam-boiler plant, if they cannot possibly be connected to a central electric station.

The power used and attendance in briquette factories varies according to their size and constructional arrangement between comparatively wide limits. In the following sections "Complete Coal Briquette Works," "The Economy of Coal-Briquetting" and "Coal Briquetting Statistics," numerous accounts of the power equipment, driving, and attendance of a number of briquette factories, partly illustrated are given and will therefore be omitted here.

SECTION IX.

COMPLETE COAL-BRIQUETTE FACTORIES. MINE POLICE REGULATIONS.

A. COMPLETE COAL-BRIQUETTE FACTORIES.

In the following pages a number of selected small and large, mostly recent and the latest, briquette factories, with more or less different equipment, are described and explained by illustrations

I. Small briquetting plant with heating oven, steam kneaders, and a Couffinhal press

As very clearly shown by fig. 87, the mixture of coal and pitch is conveyed by means of an elevator and a worm conveyor from a pit to the central charging opening of the heating oven, where it is heated, dried, and carried to the steam kneader by means of a second worm conveyor, to reach ultimately the distributing box and Couffinhal press by way of the lower opening in the kneader. The finished, compressed, and discharged briquettes slide on to a band loader, which conveys them to the railway waggon.

II. Briquette factory with steam superheater, large steam kneader, and two Couffinhal presses (Schuchtermann & Kremer system).

The arrangement of the factory is obvious from figs. 88 and 89, and the explanation given on p 195.

III. Coal separator, washing plant, and briquette factory with three heating ovens and eight Couffinhal presses at the Zeche Hagenbeck of the Mulheimer Bergwerksvereins (Plate I.).

The plant built by Schuchtermann & Kremer, Dortmund, in 1904, for a daily output of 800 tons of coal, is housed in four special buildings, which, however, form a cohesive, though lengthy unit, and is equipped in accordance with the following requirements:—

1. It shall produce pieces of coal of 80 mm. and upwards, which will be loaded directly into waggons with the addition of mixed coal,

2. The nuts of from 4 to 80 mm. must be washed, and the pieces

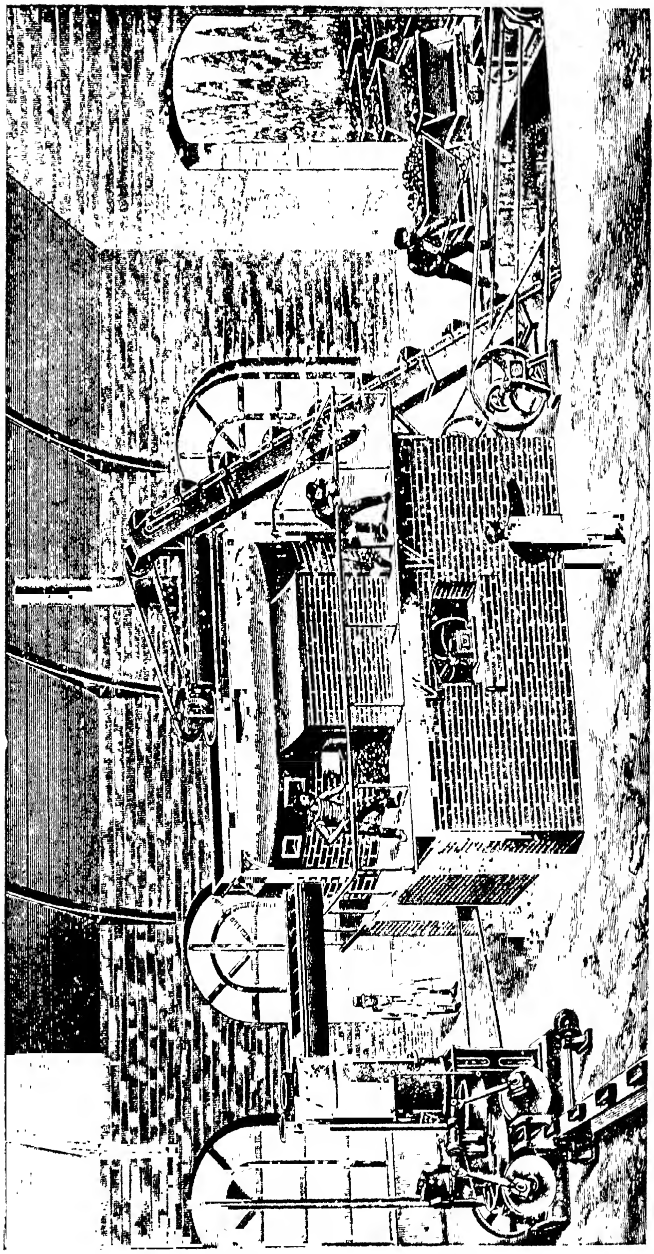


FIG. 57.—Illustration of a small briquette plant with heating oven, steam kneader, and a Couffinhal press. Schüchtermann & Kremer, Dortmund.

from 10 to 18 mm. sorted into and loaded in four grades, while the grains of 4 to 10 mm. are to be added to the dry-sieved small coal for briquetting purposes. Accordingly, the operation is arranged as follows :—

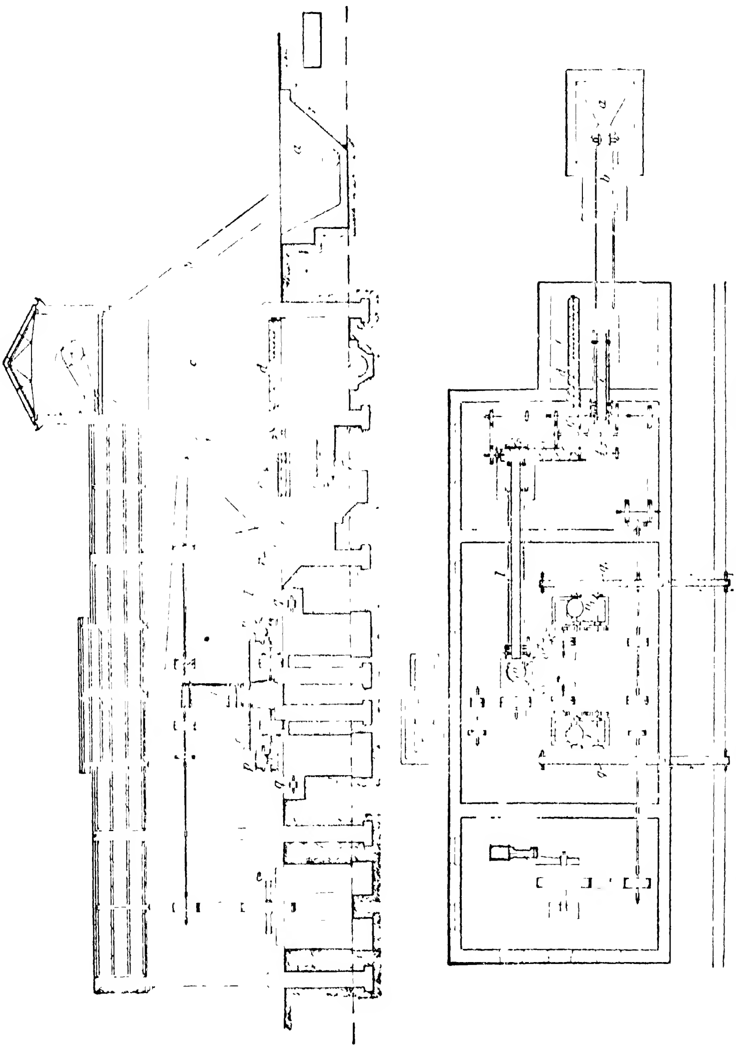
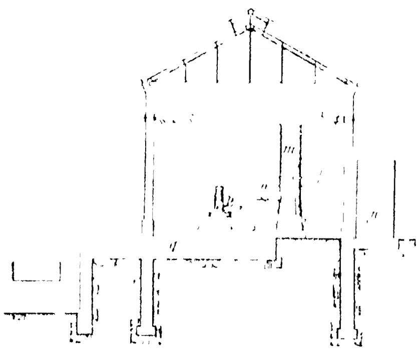


FIG. 88.—Briquette factory with [illegible] heater, [illegible] steam kneader, and two Couffinhal presses. Longitudinal section and plan. Scale = 1 : 300.

(*a*) *Separation.*—The raw coal coming from the shaft at the right by means of a chain-way is thrown on to the sieves C and D by the tipplers A and B. On the sieve C the coal is sorted into the grades 0 to 80 mm. and above 80 mm. The first grade (0 to 80 mm.) falls into

the storage pit E, while the pieces (80 mm. upwards) are conveyed to the picking band F. The sieve D separates the coal into grains from 0 to 25 mm. and 25 mm. upwards. Both grades, however, are conveyed to the picking band F to be added to the pieces of coal before loading. The separation of the coal on the sieve D has the object, first of conveying the dust of 0 to 25 mm. to the band F and of causing the coals of 25 mm. and upwards to fall on it in order to allow of a convenient clearance of these coals from the mine.

The pieces of coal from the sieve, mixed with the material from the sieve D, are conveyed to the loading band G, and from this directly to the railway waggons after previous picking on the band F. The



KEY TO FIGS. 88 and 89.

- *a* bunker for briquetting coal
- *b* coal elevator
- *c* coal storage tower
- *d* worm conveyor for coal supply
- *e* pitch elevator
- *f* centrifugal mill for pitch
- *g* coal hopper with scraper table
- *h* pitch " " " "
- *i* mixing worm
- *k* mixing pit
- *l* elevator for coal pitch mixture
- *m* steam kneader
- *n* steam superheater
- *o p* distributing worm
- *r r₁* Couffinhal presses
- *q q₁* briquette loading belt

The power plant is situated in a room to the left.

FIG. 89.—The same briquette factory. Section. Scale 1 : 300.

shale picked out is lifted into mine barrows by means of a hinged crane H and returned to the shaft by the chain-way.

(*b*) *Washing Plant.*—The main supply elevator J lifts the coal, which has to be subjected to further treatment, from the store pit E on to the sieve K in the washery. This sieve separates the fine coal of 0 to 4 mm. from that of 4 to 80 mm. The former falls on the removing shovel L, while the latter passes on to the sieve N, which separates it into five grades. Along with water, these flow to the settling machines N^1 to N^6, of which N^1 to N^4 serve to wash the first four grades, while N^5 and N^6 deal with the washing of the fifth grade. The washed coals of nuts 1 to 4 flow together with water to a grading sieve O in order to separate them into the four classes of nuts which are required in commerce. The different classes of nuts are conveyed from the pockets below the sieves to winding chutes with the greatest possible care. Nuts 1 and 2, however, have previously to pass over the picking table P or P′, where the coals are subjected to a final hand-picking.

The nuts pass from the storage pockets to the railway waggons by inclined chutes, but have to pass on their way over close sieves, on which they are sprinkled with fresh water.

The No 5 washed nuts of 4 to 10 mm flow along with water on to the swinging gutter Q, where they are drained and carried to the removal shovel L already mentioned Together with the dry-sieved fine coal they are then delivered either to the storage boxes for immediate loading by rail or to the band conveyor s, so that they can be supplied to the storage towers T of the briquetting plant. The water running away from the draining sieves and the swinging gutter flows into the drain U for clarification. The slimes which settle out are lifted to the hopper W by the elevator V fitted with perforated buckets From the hopper the mud is drawn off into waggons and delivered to the boiler-house The clear water is raised from the sump to the washery by a rotary pump The gangue washed out travels by way of the elevator X to the hopper Y, from which it is drawn off into trucks and returned to the shaft Water used for sprinkling the nuts flows into a small combined sump and is lifted to the settling sump U by the rotary pump Z

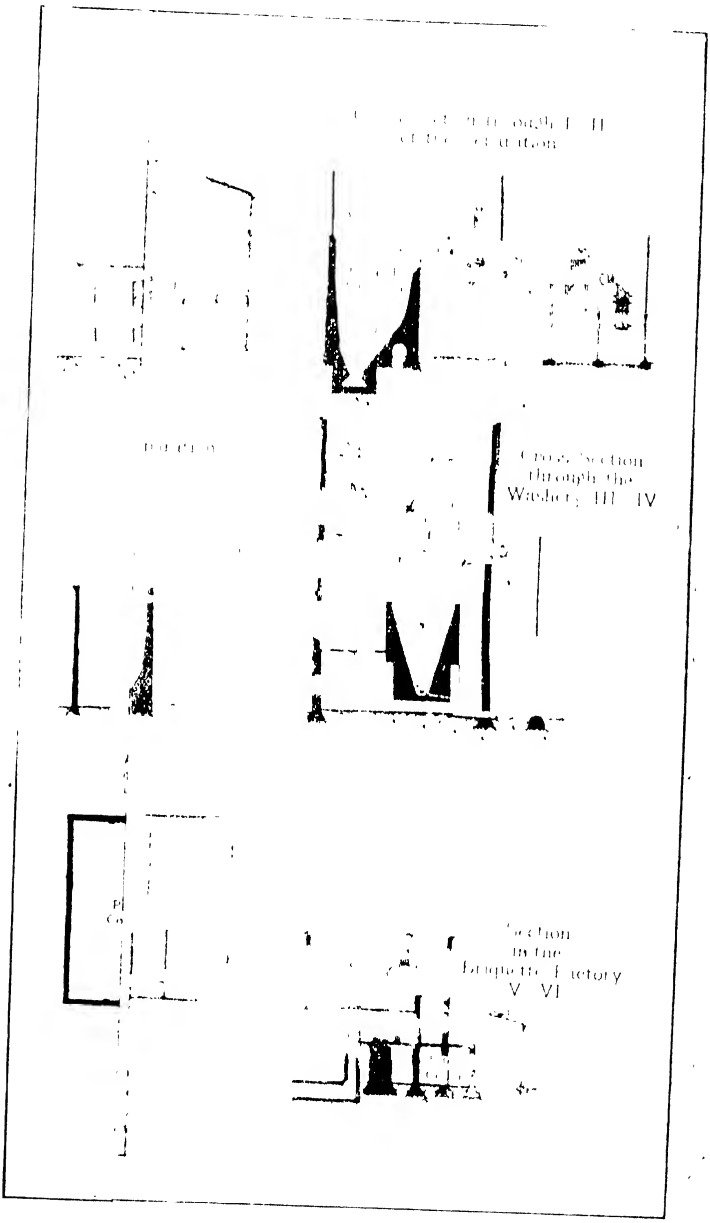
(e) *Briquette Factory*[1] —The coal for briquetting is drawn from the towers T and scraped on to the band *b* by means of the rotating table *a*. The band conveys it to the elevator *c*, which carries it to the hopper *d*, from which it is drawn off by the revolving table *e* and scraped off into the mixing worm *f*.

Pitch is broken in the stone-breaker *g*, falls on to the elevator *h* which lifts it to the disintegrator *i*, where it is ground to dust The ground pitch falls into the hopper *k*, from which the quantity required as addition is drawn off into the worm mixer by means of the revolving table *l* The mixer winds the coal-pitch mixture to the elevator *m*, which lifts it into the hopper *n*

By means of the revolving distributing disc *n'*, situated under the hopper, the briquetting material is distributed to the three heating ovens o^1 to o^3 in such a way that o^1 is supplied directly, while o^2 and o^3 are supplied from the band conveyor *p*.

In the heating oven the material is warmed sufficiently to dry the mixture and effect the fusion of the pitch. The material then travels from the oven in the eight worm conveyors q^1 to q^8 to the kneaders of

[1] The supply and mixing plant of this briquette factory, as well as the distribution of the briquetting material, are fully illustrated and explained in Section V above by figs. 22 and 23



Coke ovens. Built by Schüchtermann & Kremer, Dortmund.

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eight presses and the two exterior heating ovens o^1 and o^3 each supply two presses, while the centre oven o^2 itself supplies four presses. Here the material is compressed into briquettes of 3 kg. weight which are carried by the four bands s^1 to s^4 and loaded directly on the rail.

In an ordinary full day's working the total output of the eight presses is about 500 tons of finished briquettes.

The worm conveyor *t* with the elevator serves for the possible supply of strange coals which are carried to the works by rail.

The auxiliary conveyor *e* in the pitch cellar *w* comes into use when the principal conveyor is damaged. The space under the loading stage is used as a pitch store.

(*d*) *Driving.* The separator is driven electrically, while the remainder of the installation is driven by two Collman twin steam engines situated in a common shop behind the storage towers T and the mixing plant. Machine *y* (cylinder 350 mm. diameter by 650 mm. stroke, $n = 120$, about 150 H.P.) drives the washing plant, while machine Z (cylinder 450 mm. diameter by 900 mm. stroke, $n = 150$, about 280 H.P.) drives the briquette factory. Both engines obtain their steam from a common boiler plant.

IV. Briquette factory with a superheater and a revolver press (Yeadon-Busse). System of the Braunschweigisch-Hannoverschen Maschinenfabriken Akt.-Ges., Alfeld a. d. Leine.

Without further explanation, the arrangement of this small factory is evident from figs. 90 and 91 and the flow diagram on p. 200. Among other things, the plan shows how the briquette factory can be suitably extended by the erection of a second press and boiler in corresponding outbuildings and the output of about 5 tons briquettes per hour doubled.

V. Briquette factory with steam table driers, superheater, and two revolver presses (Yeadon-Busse), for a total hourly output of 10 tons.

The briquette factory built by the Zeitzer Eisengieszerei und Maschinenbau Aktiengesellschaft for the Freiherrl. v. Burgker Steinkohlenwerke zu Burgk (Dresden region), and put into operation in 1902, is illustrated by Plate II., figs. 92 and 93 and the flow diagram (p. 203). The arrangement and method of working is as follows:—

The washed fine coal (bituminous) below 8 mm. grain from the neighbouring Baum washing plant is conveyed to the coal store, fig. 93, above the steam drying table D by a Baum draining band. In the dryer it passes over eleven tables heated by the exhaust steam from the engines, is moved spirally by the stirrers alternately from the outside

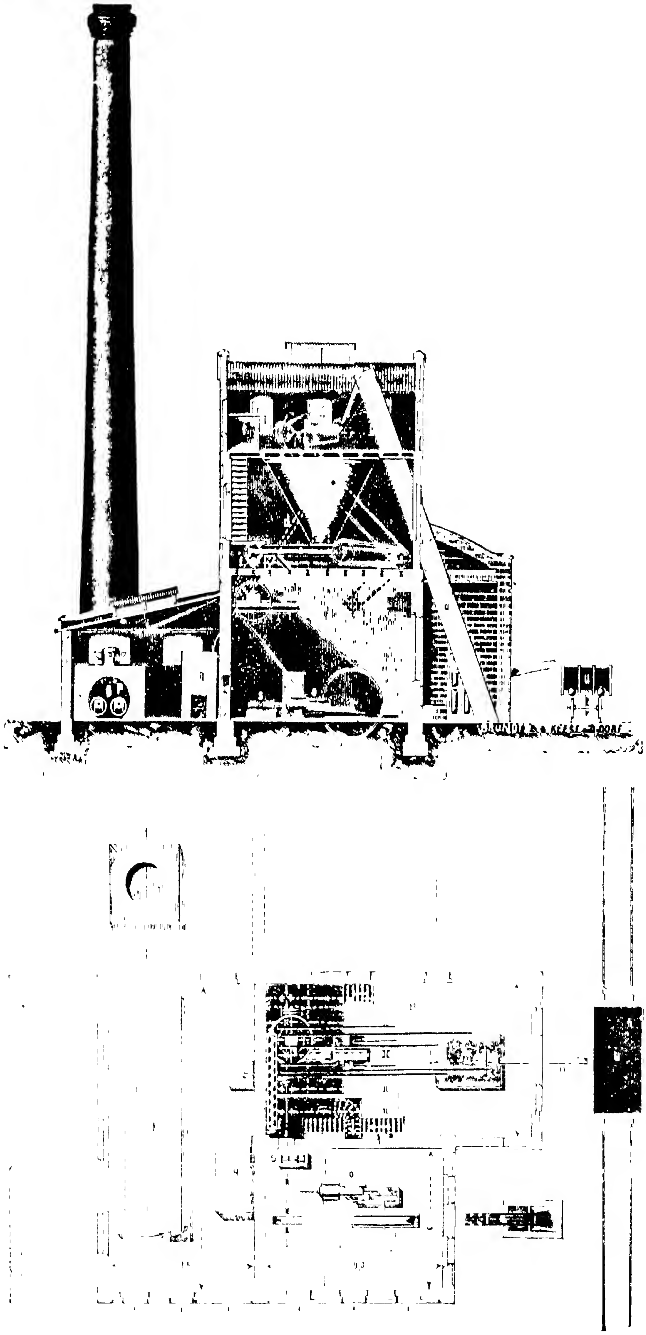


FIG. 90.—Briquette factory with superheater and a revolver press. System of the Braunschweig-isch Hannoverschen Maschinenfabriken Akt.-Ges., Alfeld a. d. Leine. Front section and plan.

to the inside and from the inside to the outside, and is lifted from the lowest table to the coal hopper T by a conveyor E_1 in an iron shed. From the funnel-shaped outfall of the hopper the coal falls on to the scraping table (fig. 92) and passes on to the mixing worm S_1.

Only about 5 per cent. of pitch[1] is required for the production of

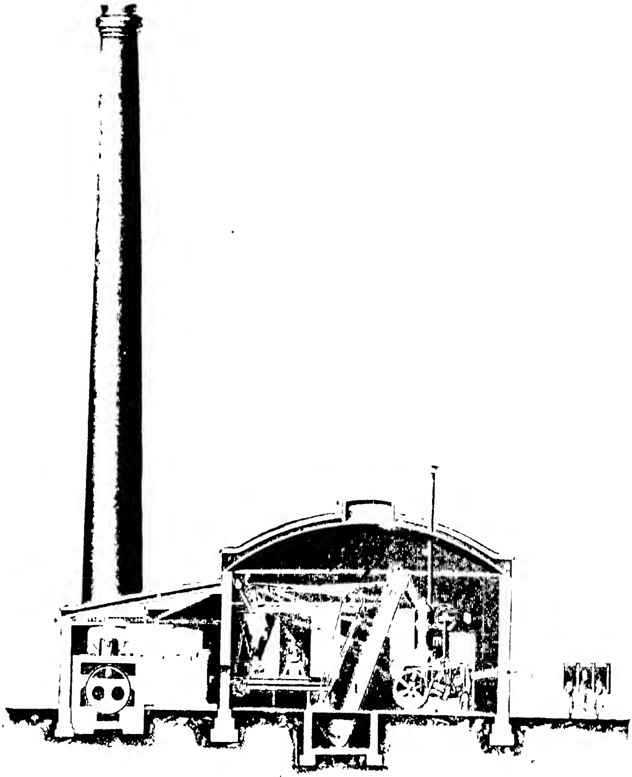
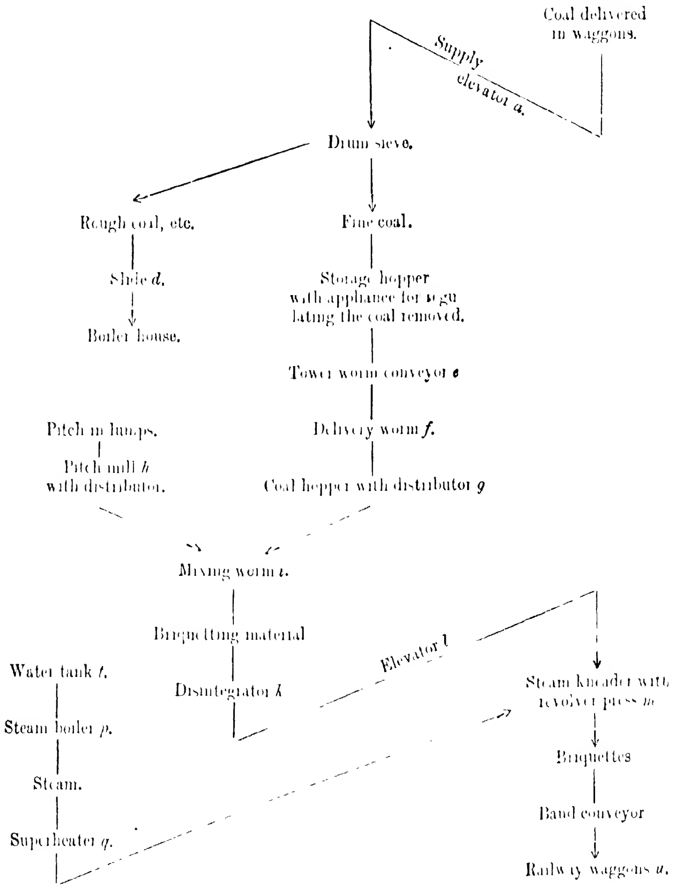


Fig. 93.—The same briquette factory. Back section. (Flow diagram of the briquette factory illustrated in Figs. 90 and 91.)

strong briquettes. The pitch is taken from the store according to requirements, and delivered to the cracker P at definite intervals of time. Here it is crushed and carried to the short worm conveyor, which carries it to the mixing worm S_1 situated below, in which the pitch is combined with the fine coal. The mixture then slides to the disintegrator G for intimate mixture and pulverisation. From here it is carried by means of the elevator E_2, enclosed so as to be dust-tight,

[1] A medium soft pitch, which changes its shape in two or three minutes in a water bath at 58° C., is applied.

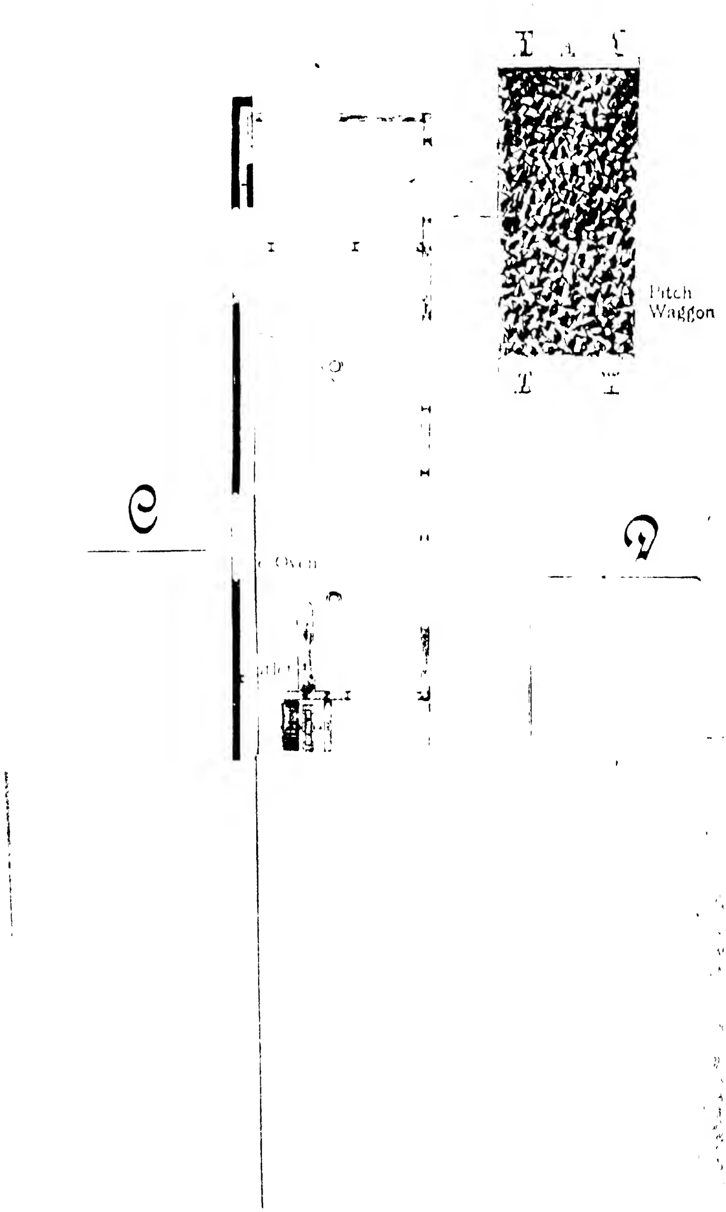
and the distributing worm S_2 to the steam kneader of the two revolver presses (Yeadon-Busse), where it is thoroughly kneaded and subjected to the action of superheated steam at about 200° C. After compression



"Flow diagram" of briquette factory (figs 90 and 91)

the finished briquettes are conveyed to the waggons by a band conveyor The machinery is driven by a single-cylinder steam-engine of 60 H.P.

Output.—Each of the two presses which can be operated simultaneously, has an hourly output of about 5 tons The large press delivers at each stroke six briquettes of ¾ kg. for domestic purposes. The smaller press delivers at each stroke, four briquettes of 1 kg. for consumption in locomotives.


Pitch
Waggon
Oven

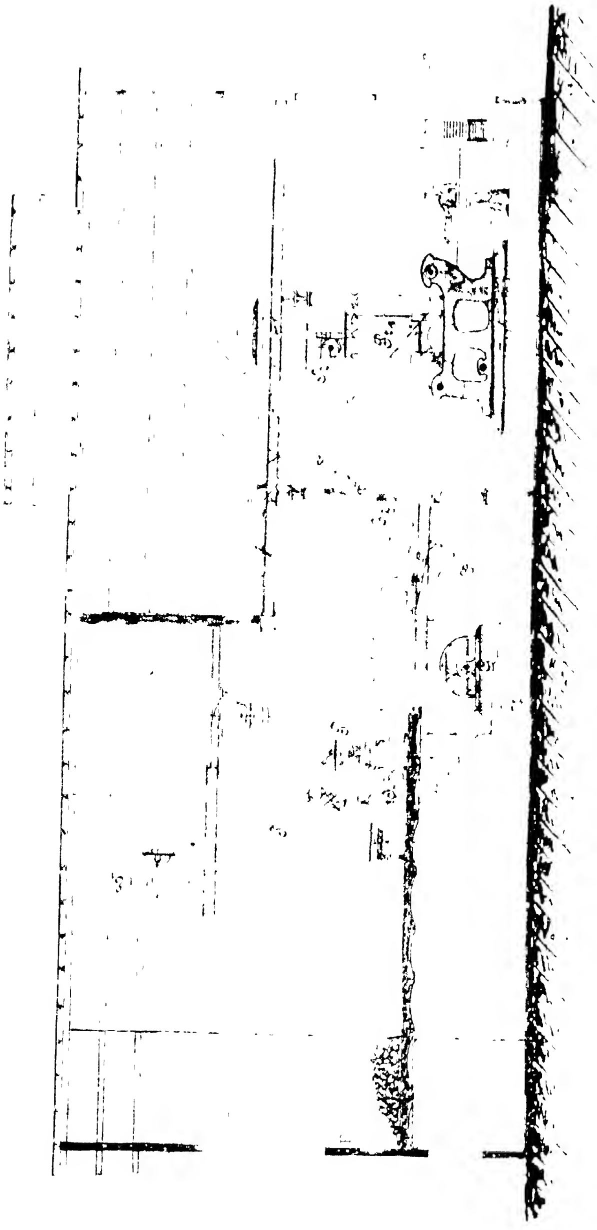


FIG. 92.—Bri[illegible] steam table dry[illegible] A–B Fig. II [illegible]

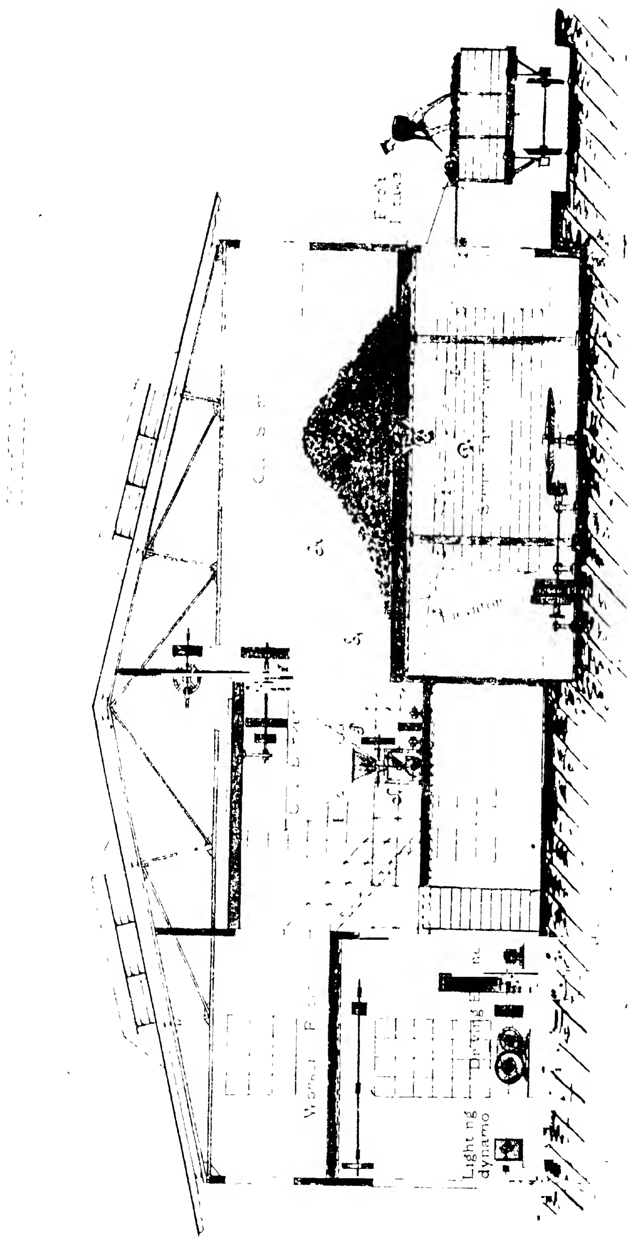
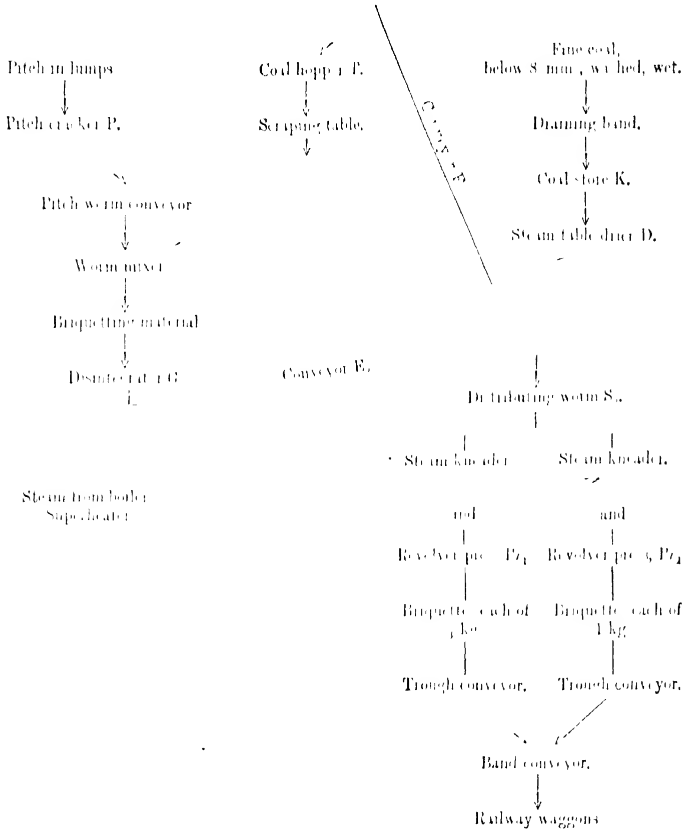


FIG. 93.—The same [illegible] Section C–D [illegible] H).

With a production of about 12 000 tons of briquettes per annum, the costs of manufacture amount to 5 to 6 marks per ton according to the prices of pitch This includes the cost of loading, the relatively



"Flow diagram" of the briquette factory of the Freiherrl v Burgker Steinkohlenwerke zu Burgk (Dresden region)

extensive repairs (namely, to the steam table ovens and the presses), as well as depreciation

VI. Briquette factory with fire-heated drum drier and two revolver presses (Model II), according to the new system of the Zeitzer Eisengiesserei (Plate III)

Hourly output: about 13 tons of 1-kg briquettes

The water content of the coal may be anything up to 20 per cent, and the size of the grains anything up to 13 mm

Crude coal is elevated by the elevator *a* to the hopper *b*, from which it is passed to the drying drum *d* (Zeitzer Eisengieszerei's patent) quite uniformly by the distributing table *c* standing underneath. The elevator *e* removes the coal dried to 5 per cent. moisture into the combined hopper *f*, from which it is passed to the worm mixer *j* by means of the distributing table *g*.

In the pitch cellar, pitch is broken into pieces about the size of the fist and conveyed to the cracker *i* by the elevator *h*. It is broken into pieces about the size of hazel nuts and also passed into the mixing worm *j* by means of the distributing table below the cracker.

The coal pitch mixture is now passed to the disintegrator *k*, where it is finely ground and passed on to the hopper *m* by the conveyor *l*. By means of the distributing table *n* the mixed material is delivered on two sides into worm conveyors *o*, which convey the material to the left and right into the steam kneaders *p* and the revolver presses *q*. The finished briquettes are removed from the presses automatically on to the band conveyor *r*, which carries them to the railway loading stage.

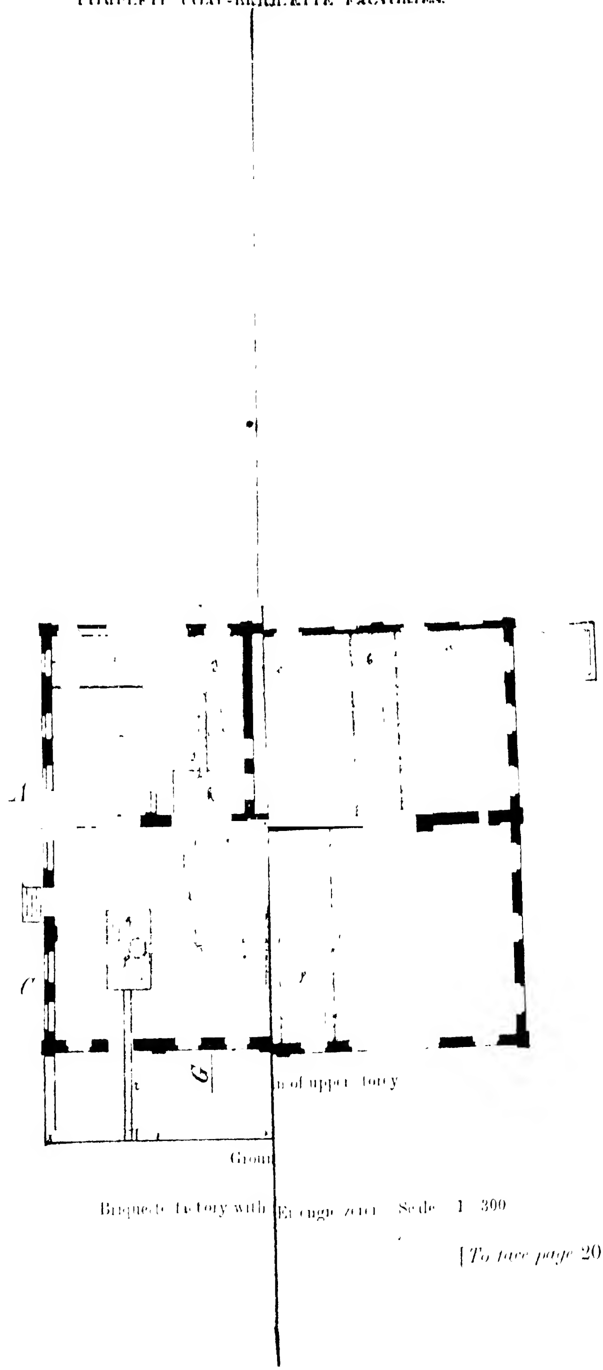
VII. Briquette factory with three steam table driers and three toggle joint presses of the Tigler system at the State pit in Upper Silesia (figs. 94 to 96).

Total hourly output: 15 tons briquettes of 3 and 6 kg. weight.

The whole of the internal equipment of the briquette factory built on the eastern field of the State mine (Kgl. Berginspektion I., Konigshutte O.-S.) in 1906–07, was provided by the Maschinenbau-Aktiengesellschaft Tigler of Duisburg-Meiderich, while the buildings were erected by the Ver. Konigs- und Laura-hutte Aktiengesellschaft, Berlin (Konigshutte section).

Briquettes are produced from small flaming coal varying from 0–13 mm. in grain size, obtained by the dry treatment of the coal as delivered in Gerhard, Heintzmann, and Sattel separators. This material contains on an average from 9 to 10 per cent. of moisture, and during the spring and summer of 1908 could be purchased at a price of 4·90 to 5·50 marks per ton. The binding material employed is a hard pitch whose melting-point lies between 60° and 70° C. It is added to the coal in such quantities that the resulting briquetting material contains from 6·5 to 6·7 per cent.

The pitch is delivered by the Oberschlesischen Kohlen- und Kokswerken Aktiengesellschaft, Berlin, and is usually obtained from the Koksanstalt Zabize. Its price is 33 to 35 marks per ton.



Briquette factory with Ex engine zero. Scale 1 : 300

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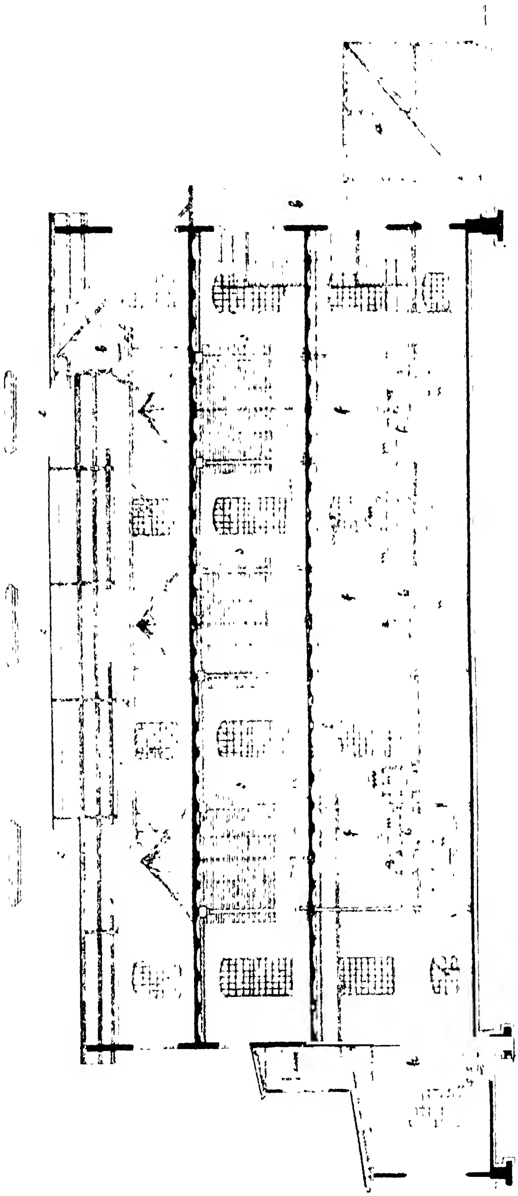

Fig. 94.—B[illegible]

Fig. 95.—Briquette factory with three steam table drives in field toggle joint presses, Tdl system at Königsgrube O.-S. Plan. Scale = 1 : 200.

The complete plant is organised as follows. The tall shop at the back contains, in addition to the coal conveyor, which is situated at the right in front of its narrow side, the coal storage and supply room at the top, below which is the drying room next to the vapour flue which is carried upwards at the back. In the lower storey is situated the mixing plant for coal and pitch as well as the main transmission. The lower storage shop at the front contains the

FIG. 96.—The same briquette factory at Königsgrube O. S. Section E F (see fig. 95). Scale 1 : 200.

disintegrators, the elevators for the briquetting material, the steam kneaders, and the briquette presses, as well as the worm conveyors and loading bands. The latter run over the covered loading stage, which is built in front towards the railway. In small outhouses on the right-hand side of the building in front of the coal conveyors described are to be found the motor *u*, driving the whole plant, and the manager's office *w*. In front are the two steam superheaters *v*, and on the left-hand side of the building is the pitch store.

In detail the operation of the plant is effected as follows:—The coal dust is for the most part delivered into waggons at the pit top, tipped into the storage hopper *a*, and falls from the lower mouth into the coal elevator *b*. In addition about 150 tons daily is blown

through a pipe 10 cm. diameter by means of air at 0·2 atms. excess pressure. The elevator lifts the coal dust up to the roof loft and delivers it through a small hopper provided with a slide, on to a band conveyor *e* running the whole length of the coal floor. The band conveyor distributes the coal partly with the aid of inclined scrapers into three heaps, during full working of the factory, which are piled up above the three steam table driers (Busse-Tigler, see pp. 81–84). In each appliance, with the aid of a stirrer, the coal is moved from above downwards in the well-known manner, and by means of the steam led through the hollow tables at 4½ atms. above atmospheric pressure it is dried to 1 to 2 per cent. moisture. The coal is thoroughly mixed, and finally allowed to fall into the hopper *f* situated below, while the steam given off escapes into the open through the stack *e*. From the hopper *f* the coal passes on to a revolving table (distributor *g*), where it is scraped in regular definite quantities into the corresponding worm conveyors and mixers *h*. At this point the combination with the pitch occurs. The hard pitch is first broken up in the pitch-breaker *i* standing in the pitch store, then it is lifted by the vertical elevator *k* on to the band conveyor *l*, which runs along under the roof of the ground or press floor and discharges the pitch into the receivers of the two so-called pitch distributors. These deliver it in the proportions already stated into the worm conveyors, which carry it to the previously described worm mixers and conveyors *h* situated at right angles, where the pitch and dried coal are mixed together.

The coal-pitch mixture thus obtained is delivered to a disintegrator *n* from each worm mixer, ground, lifted to a steam kneader *p* by an elevator *o*, subjected to a thorough kneading with the aid of superheated steam at 250° to 300° C. from the superheaters *e*, conveyed to one of three toggle-joint presses *r* of the latest Tigler type (see p. 158 *et seq.*) by one of the worm conveyors *q*, and finally compressed to briquettes.

The finished briquettes pass on the loading bands *s* to the railway waggons for transport. At the present time their selling price is 12·50 marks per ton.

The plant came into regular operation in February 1908. The capacity for output is returned as 45 tons per hour, or 400 tons per day (9-hour shift), with three presses in operation.

At present, however, only two presses are equipped and in operation, and have an hourly output of about 30 tons per hour.

One press delivers at each compression eight briquettes, each of

3 kg. weight. The other press delivers at each compression four briquettes, each of 6 kg weight.

The motor which drives the whole factory can generate 280 H P at 6000 volts, but at the present time only generates 200 H P for the operation of the two presses. The costs per kilowatt hour amount to 3 70 marks.

Staff and Wages	Pay Rate	Daily Wages for the Operation of Two Presses	Daily Wages for the Operation of Three Presses
	M	M	M
1 briquette manager	5 25	5 25	5 25
For each press —			
2 men at the press itself	3 50	14 00	21 00
1 man on the coal floor	3 25–3 50	about 6 80	about 10 20
1 „ at the drier	3 25–3 50	„ 6 70	„ 10 05
For the whole plant —			
1 man in the pitch cellar	2 75		
1 „ at the „ distributor	3 25	„ 13 40	„ 13 40
1 „ „ superheater	3 25–3 50		
1 motor attendant	4 00		
10 boys for loading	1 50	15 00	15 00
3 men for removing waste, arranging railway waggons, and so on	2 75	8 25	8 25
	Total	about 69 10	about 83 15
		or	
		$\frac{69\ 10}{250}$ = 0 28	$\frac{83\ 15}{400}$ = 0 21
		per ton of briquettes.	

These labour costs are to be regarded as very low.

Further, the use of 6.5 to 6.7 per cent pitch is in itself, and also in comparison with other Upper Silesian briquette factories, very small in consequence of the thorough drying of the raw coal. With an average pitch price of 34 marks per ton, the costs only amount to 2 21 to 2 28 marks per ton of briquettes. On the other hand, the use of fresh steam from the boilers instead of waste steam from the engines appears to be less economical, and is only occasioned by special local circumstances.

The total cost of the installation amounts to 340,000 marks of which 160,000 marks fall to the erection of the buildings, and 180,000 marks to the internal equipment.

The plant has not been in operation long enough for a definite opinion to be given on the efficiency of its equipment and a specially useful report to be made on the magnitude of the total costs of running and repairs.

VIII. Briquette factory with four toggle-joint presses—Model II., Schuring patent—and superheater (figs. 97 to 100).

Total hourly output: 66 tons briquettes of 3 to 4 kg., or 74 tons briquettes of 6 to 8 kg.

(Zeitzer Eisengieszerei und Maschinenbau Aktiengesellschaft design, spring 1908.)

The idea underlying the design is to permit the working of the plant in two systems, so that each pair of briquette presses constitutes a complete unit, and consequently the possibility of being

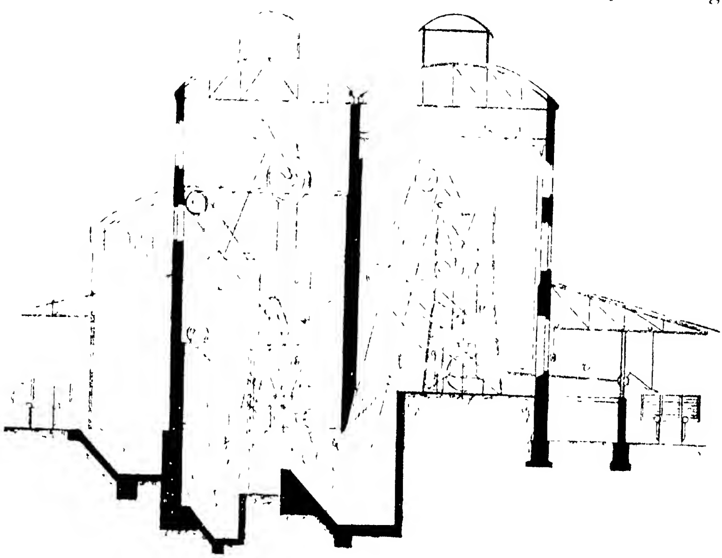

FIG. 97. Briquette factory with four toggle-joint presses—Schuring patent—and superheater. Section. Scale = 1 : 300.

able to work with half of the plant is attained. Further, it was assumed that a mixture of two kinds of coal would be worked up; consequently, two coal hoppers, each of about 22 tons content, with distributing tables below, are arranged for each system. It is also possible to produce 3- to 4-kg. briquettes with one system and 6- to 8-kg. briquettes with the other. Since drying is not carried out, the coal must not contain more than 5 to 6 per cent. moisture.

Briefly, the method of manufacture is as follows:—

Elevators *a* lift the raw coal into the drum sieves *b*, which separate out the coarse pieces over 13 mm., as well as the foreign materials.

Below the drum sieves are situated hoppers ending in V chutes

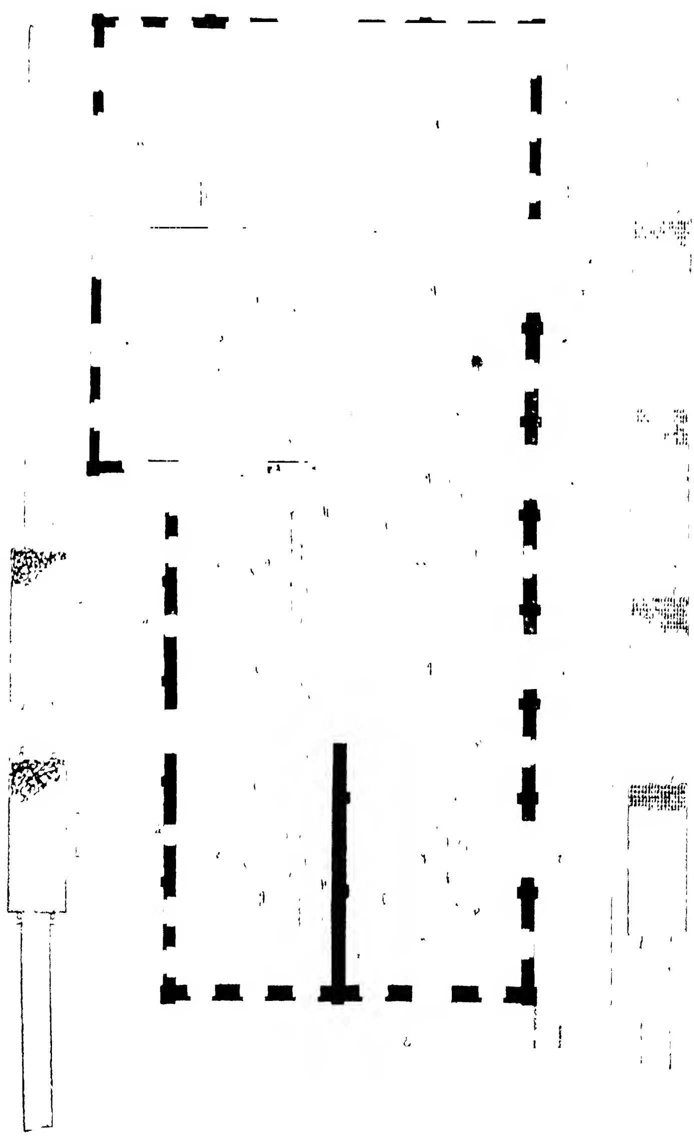

FIG. 98.—The same briquette factory as in fig. 97. Plan. Scale = 1 : 300.

provided with reversing valves, by means of which the sieved coal is introduced alternately into the hoppers *c* (fig. 99).

The pitch, which is stored in a cellar, is broken into pieces of the size of nuts by means of the pitch-breaker *e*, then transferred into the disintegrators *g* by the elevators *f*, and reaches the hopper *h* in the form of fine dust.

Below the hoppers *c* and *h* are placed the distributing tables *d* and *i*, which transfer the coal and pitch in the correct proportions to the worm mixtures *j*, which in turn convey the mixture to the disintegrators *k*. The ground mixture is carried by the elevators *l* into the hopper *m*, and by means of the distributor *n* standing underneath is transferred to the steam kneaders *p*, partly direct and partly by the worm conveyors *o*. Here it is treated and thoroughly kneaded under the action of superheated steam at about 300° C.

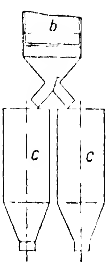

Fig. 99.

The material ready for pressing is then conveyed to the toggle-joint presses *q* (Model II., Schuring patent). The finished briquettes then arrive at the belt conveyor ready for loading in waggons.

IX. Briquette factory with steam kneader and two egg-roll presses by Hanrez-Zimmermann & Co. (fig. 101).[1]

This firm of Monteeau-sur-Sambre (Belgium) has built several plants of this type for briquette factories producing egg briquettes, and also for several Westphalian mining companies. The drive is obtained from the steam-engine *a* by means of the transmission *i*. The mixture of coal and pitch is conveyed from the distributor *b* to a disintegrator *c*, where it is finely ground, thoroughly mixed, and elevated from a masonry charging hopper to a large steam kneader (*malaxeur*) by means of the elevator *e*.

After the briquetting material has been thoroughly stirred up under the action of superheated steam, it is removed from the bottom at both sides to worms *f*, which convey it to the distributing tables *g* of the two egg-roll presses *h*. The rolled egg briquettes slide down chutes into railway waggons for transport.

X. Anthracite and coke briquette factory of the United Gas Improvement Co., Philadelphia, at Point Breeze in Pennsylvania.[2]

This plant, illustrated by figs. 102 and 103, is one of the latest and

[1] *Niederheim. Westfal. Sammelwerke*, vol. IX., 1905, pp. 620-621.

[2] E. W. Parker, "Coal Briquetting in the United States," *Bi-monthly Bulletin of the American Institute of Mining Engineers*, 1907, pp. 807-811.

best equipped of the not very numerous briquette factories existing in the United States up to the present (compare pp. 263–264). The United Gas Improvement Co. work up a mixture of small anthracite (culm)

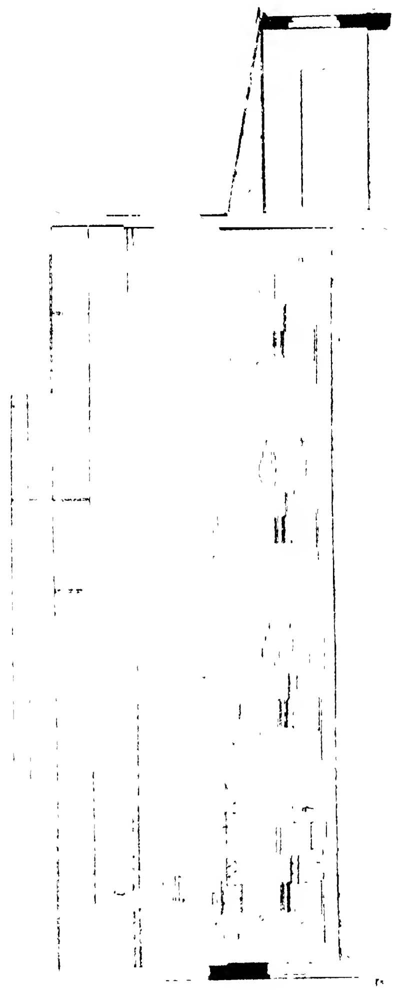

FIG. 1[illegible] —The [illegible]

and the quenched coke containing 5 to 7 per cent coal-tar pitch obtained in gas manufacture and use the briquettes in their own works for the production of water gas. The proportion of anthracite to coke varies with the quantities of materials available at the time. In November 1906, for example, three parts of culm were added to two parts coke.

The press is a roll press of Belgian type, and makes egg briquettes of the size of goose-eggs. The output of the plant amounts to 10 tons per hour, or 90 tons per day of 9 hours.

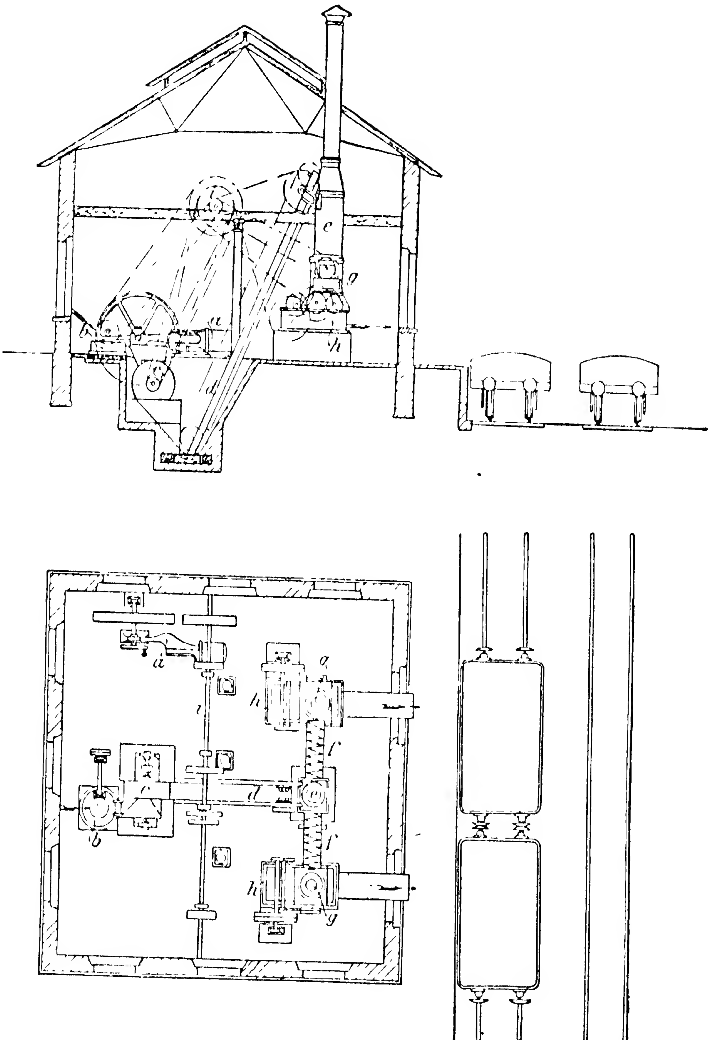

FIG. 101.—Briquette factory with steam kneader and two egg roll presses by Hamez-Zimmermann. Section and plan.

Sieved, quenched coke from the gas plant falls into the charging hopper A, into which the anthracite coal is also charged. By means of an elevator the content is lifted to the cylindrical storage-holder B,

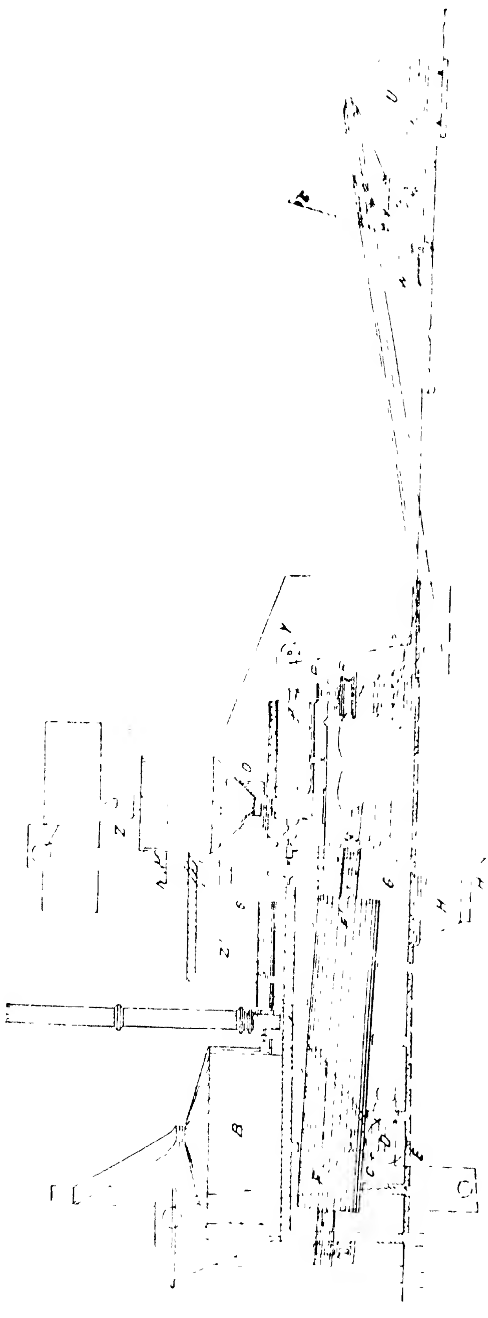

FIG. 102.—Anthracite and coke [illegible]

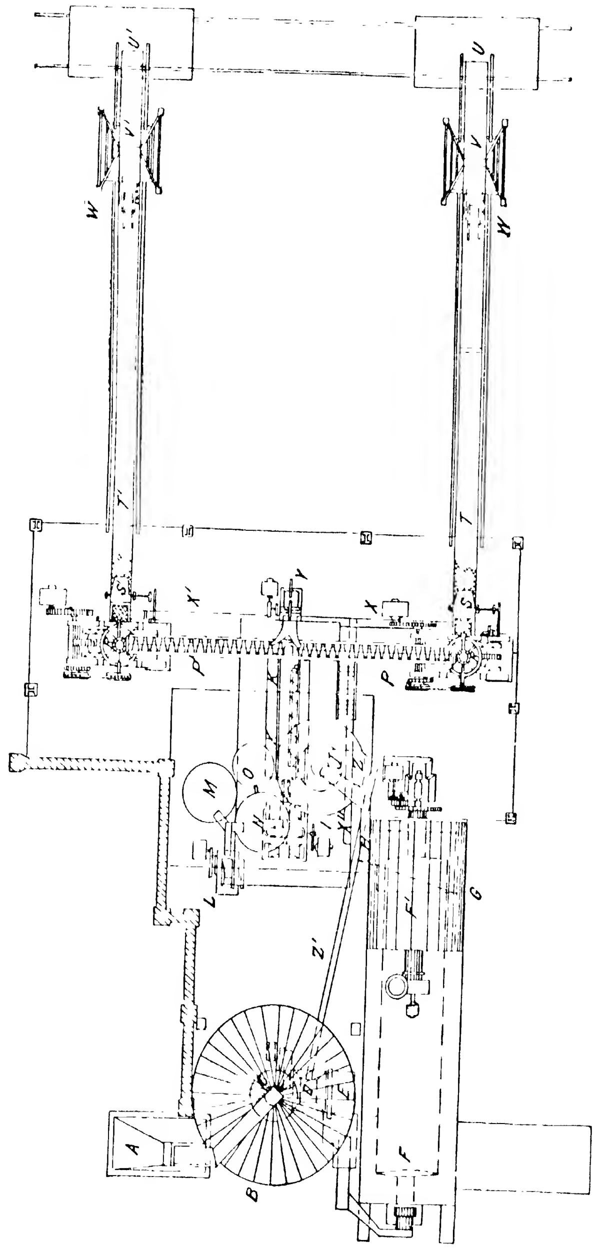

Fig. 103.—The same briquette factory as in fig. 102. Plan.

from the hopper at the bottom of which it is transferred to the automatic supply table C, and from here in measured quantities partly to the breaker D and partly direct into the charging hopper E below the crusher.

A second elevator lifts the material and drops it into the drying drum F F'. The dried material is together with the dust from the dust chamber G G' of the drier, carried to the charging hopper H H', but is again elevated and shaken into the container above the mixer K K' by means of a shaking sieve Z. All the coarse material which will not pass the sieve Z is deflected by an inclined tube Z' back to the crusher.

From the funnel-shaped bottom of each container the sieved dried material is drawn off on to the automatic supply table J, from which a measured stream flows continually into the mixer K. At the same time an unbroken stream of liquid pitch is led into the left supply end of the worm mixer through an accurately fixed measuring cock not shown in the illustration.

The pitch is obtained in solid broken pieces from the tar distillation, is pulverised in the pitch-breaker L, then elevated and shot into the large steam-heated pitch tank M N, where it melts. From this tank the molten pitch is drawn off according to requirements into the small steam heated vessel *o*, to which the measuring cock already described is attached.

The warm, dried and pulverised culm coke mixture is now, along with the molten pitch, thoroughly mixed up in a steam-jacketed mixer K, kneaded, and on discharge is divided into two streams which are delivered to the supply pans of two presses R R', where the mixture cools down. The presses are of French origin. They prepare egg briquettes and carry them into shaking sieves S S', where broken pieces and fine waste are removed. The briquettes pass on to the loading bands T T' of wire-netting, which travel upwards and shoot the briquettes either into the waggons U U' or the bins V V'. On the way they have time to cool and to set. From the bins V V' the briquettes are filled into large hand-barrows W W' for conveyance to the generator house.

The breakage and waste from the shaking sieve S S' is carried back to the charging hopper H at the exit of the drier by means of the conveyors X X'. Sieve waste from the briquettes taken from the heaps in the store is lifted by the elevator Y to the outfall of the mixer, where it assists in the cooling of the heated mixture.

XI. Problems in the scheme of coal-briquetting plants. The Maschinenbauanstalt Humboldt, Kalk, near Koln, issue, in cases where inquiries are sent to them, the following very appropriate question sheets, which, when answered by the orderer of a briquetting plant, puts the firm in possession of the requirements:—

1. Nature of the crude material. What is the kind of coal? Is it of the nature of a flaming, fat, or smithy coal?

2. Moisture content. Is the coal dry or moist? In the latter case how great is the moisture content?

3. Degree of fineness. What is the greatest grain size of the material to be briquetted?

4. Output. What output is to be obtained in 10 hours?

5. Weight. What weight of individual briquettes has to be provided for—$\frac{1}{4}$ kg., $\frac{1}{2}$ kg., $\frac{3}{4}$ kg., 1 kg., $1\frac{1}{4}$ kg., $2\frac{1}{2}$ kg, 3 kg., 5 kg., 6 kg., 7 kg., 8 kg., or 10 kg.?

6. Space conditions. If a complete new plant is projected, a plan of the position should be sent; otherwise a free-hand sketch, with sizes of the existing buildings, indications of the transmission provided with the number of revolutions as well as a statement of the horse-power available for working purposes.

7. Railway installation. Altitude of the ground-floor of the building above the upper edge of the rails.

8. Buildings (for new construction). Are the buildings to be of iron construction, brickwork, or completely of timber?

9. Driving power. Is a motor already provided? What is its description, position, power, and number of revolutions? What are the measurements of its driving pulley? Or shall the firm provide the motor, and of what kind must it be?

In cases where a steam-engine is required, what is the highest permissible steam pressure in the existing boiler, and what pressure is usually available at the place of use? Or shall the firm deliver the boiler, and what fuel must it be fired with?

10. Experiments. These are only necessary when the practice or earlier experiments have not provided the firm with experience of the material to be briquetted. In order to determine whether experiments are necessary or not, a request is made that 5 to 10 kg. of the raw material shall be sent along with the preliminary inquiries. The firm will then supply the information whether a test compression must be made or not, and what quantity of material is required for the test.

B. INSPECTION OF MINES REGULATIONS.

There are no special police regulations for coal-briquetting factories. However, inasmuch as the latter often belong to mining companies, there are certain mine police regulations of a general nature to which they must conform

In the Dortmund Mining Commission's district they are provided for in the Mine Inspection Decree of the 28th March 1902 on the "Working Plants at Collieries," containing pertinent rules on "Day Installations" (I) as well as on "Boilers and Engines" (V.) In the remaining districts of the Prussian Mining Commissions similar regulations are enforced. In the kingdom of Saxony there exist special Mine Inspection Decrees for individual briquette works. The Saxony Board of Mines at Freiberg on the 12th March 1902 issued on the basis of §§ 55 and 56 of the General Mining Laws of 16th June 1868 the following decree for the operation of a coal briquetting factory at Zwickau[1]. —

I.

1. The room in which the power machines are situated must be connected with the other rooms in the factory by means of signalling appliances

2. Illumination of the factory rooms must be effected by glow-lamps, which must be surrounded by a glass globe and wire-netting

3. The electric leads, lamps, and machinery must correspond exactly with the safety regulations of the Institution of German Electrical Engineers.

4. Arrangements must be provided to show at any time the pressure or temperature of the steam used for heating the drying arrangements

5. Further arrangements must be made to hinder as far as possible the formation of coal dust outside the apparatus.

6. Inside those rooms of the factory in which coal dust can be deposited the bearings of rotating parts must be provided with automatic lubricators.

7. In the rooms of the factory sufficient sprinklers, easy to set in action, must be arranged in such a manner that at any time every part of the factory can be subjected to a stream of water.

[1] E. Treptow, "Das Brikettieren der Steinkohlen im Konigreich Sachsen," *Sachsen Jahrbuch*, 1907.

II.

1 The floor of the press-house must be sprinkled with water daily. All rooms in the factory in which the development of coal dust takes place must be cleansed from dust in all its parts at least once a week, the dust must also be removed from the hollows.

2. An order of signalling must be laid down, for which purpose a draft of the following signals must be arranged at the very least:—

(1) The operation of the driving engine commences.

(2) The engines are to be stopped (halt signal).

(3) There is a fire in the factory.

The signal orders must be made known on tables near the signalling appliances

3. As soon as the daylight becomes bad, the places where workers are employed continually must be illuminated sufficiently If this is not effected by glow-lamps, safety-lamps only must be employed.

4 Smoking must be prohibited in the rooms of the factory. This order is to be made known by notices at suitable places.

5 For the remainder the pertinent orders of the General Mine Inspection Regulations of the 2nd January 1901, and particularly the paragraphs 18, 21, 27, and 30, are also to be observed.

III.

Before the beginning of the regular operation the Oelsnitz Royal Mine Inspection must be informed in sufficient time for a previous official testing of the installation to take place.

SECTION X.

THE ECONOMY OF COAL-BRIQUETTING.

COSTS.

THE economical success of briquetting is in general determined on the one hand by the cost of the installation and the total costs of the production of briquettes, but above all by the cost of the raw materials for briquetting (coal and pitch), and on the other hand by the selling price of the briquettes.

The cost of the plant in a briquette factory, even under similar circumstances and similar equipment, will vary according to the prices of materials, wages, and conditions of the market at the time of the estimate or construction, often also according to competition and other business considerations, so that definite figures cannot be given. Further, the costs of production of briquettes under the same methods of manufacture and management are naturally subject to certain variations, namely, according to the amount for liquidation and paying interest on the cost of the installation, the ruling prices for coal and binding material (pitch), wages, and so on. The following estimates of costs, profits, and revenues have therefore only a conditional value; they correspond roughly to the average conditions for 1908 and can therefore be taken for the present and the near future if supported with some caution, but need suitable allowances when considerable changes take place in this or that factor. In other respects, as in all other industrial installations, the profit and revenue of a briquette works increases with its size and output, since, not only large works are relatively cheaper in first costs, but they also make better use of the appliances and workers and admit of the possibility of cheaper management, and since, in addition, the general costs of the whole undertaking to which they belong are distributed among a larger number of units of production.

A. ESTIMATE OF THE COSTS OF PLANT AND ERECTION OF A COAL-BRIQUETTE FACTORY WITH HEATING OVENS, 2 COUFFINHAL PRESSES, AND BOILER-HOUSE—TO YIELD FROM 100 TO 110 TONS FINISHED 3-KG. BRIQUETTES IN 10 WORKING HOURS.

I. Cost of Plant.

1. Building for two double 3-kg. presses with heating oven, engine-house, storage tower, mixing room, in massive masonry, with iron-work in the interior and iron-work roof construction .	45,000 marks.
2. Boiler-house with massive outer walls, iron roof girders, and sheet-iron covering for well . .	6,000 „
3. A massive chamber	3,000 „
4. Steam boiler with 80 sq. metre heating surface for a pressure of 8 atms above atmospheric, with coarse and fine adjustment ready bricked in	11 000 „
5. The complete mechanical appliances, with exception of the presses	40,000 „
6. Double 3-kg. Couffinhal press	30,000 „
7 For unforeseen circumstances and finishing off	2,000 „
Total	137,000 marks

In the addition of a briquette factory to a sufficiently powerful existing boiler plant, the sum would be modified by the sums shown in 2, 3, and 4 = 20,000 marks, and the total would then amount to 120,000 marks. The cost of installation of a two-press briquette factory with steam superheater and a large steam kneader, instead of the heating oven, is about 15,000 marks lower, and amounts, with a special boiler plant, to about 125,000 marks; without the boiler plant to about 110,000 marks.

II. Costs of Production.

(*a*) *Net Working Costs.*—On the basis of the costs of installation given for the two-press factory with heating oven and boiler plant, the following are the working costs on an ample scale for a yearly production of $100 \times 300 = 30,000$ tons of finished briquettes.

		Yearly	Per ton of Briquettes
		M	M
1. Interest on and liquidation[1] of cost of plant, each 5 per cent., together equals 10 per cent. of 140,000 marks		14,000	0·46
2. Raw material for briquetting alone—			
(a) 27,900 tons briquetting coal (= 93 per cent. of the production of briquettes) at 8·50 marks[2] per ton		237,150	7·95
(b) 2100 tons pitch (= 7 per cent. of the production of briquettes) at 40 marks[3] per ton		84,000	2·80
3. Workers' wages—			
1 briquette manager (7·50 marks per day) for 300 working days	2250 M		
1 engine and boiler attendant (5·60 marks)	1680 ,,		
3 men on the pitch supply and mixing plant (4·25 marks)	3825 ,,		
1 man at the heating oven or the superheater (4·25 marks)	1275 ,,		
2 men at the presses (6 marks)	2100 ,,		
6 boys for loading (2·25 marks)	4050 ,,		
14 men at a total wage of		15,180	0·52
4. Working materials—			
(a) Boiler coal for heating the boilers and heating oven or superheater, 1000 tons (= 3⅓ per cent. of the briquettes produced) at 8·50 marks per ton		8,500	0·25
(b) Oil, cleaning waste, and other materials		8,500	0·05
5. Repairs and replacements		2,700	0·09
6. Remaining costs		1,670	0·05
Total		365,000	12·17

According to this, the pure costs of production or net working costs amount to $\frac{365,000}{30,000} = 12·17$ marks per ton of briquettes.

Their not inconsiderable magnitude is caused principally by the high value which has been taken for the briquetting coal, which alone accounts for 7·95 marks per ton of briquettes. If this be subtracted, the total costs of manufacture are seen to be 12·17 − 7·95 = 4·22 marks per ton of briquettes.

The main portion of this falls to the cost of the pitch, which at the comparatively high pitch price of 40 marks per ton which has been

[1] For liquidation of the total costs of the installation 5 per cent. has been taken here. Individually, taking 2 per cent. for buildings, 4 per cent. for the boiler, and 7 per cent. for the complete mechanical appliances, including the presses, with regard to the comparatively slow speed, the total amount for liquidation works out at 6770, which corresponds closely to the 5 per cent. given above.

[2] In the Lower Rhenish Westphalian district the approximate value of the small coal for briquetting in the year 1907 amounted, per ton, to 6·75 marks (hard coal), 8·50 marks (smithy coal), and 11·80 marks (fat coal). The amount inserted here, therefore, corresponds to the price of smithy coal, which in 1907 formed almost 60 per cent. of the total coal briquetted (see p. 241).

[3] In the year 1907 the price of pitch varied from 40·50 to 39 marks, according to the statement of the Coal Syndicate (*ibid.*).

inserted, works out at 2·80 marks = 23 per cent. of the total net working costs and 66·3 per cent. of the costs of manufacture.

Labour costs form the next highest item, but at 0·52 mark per ton of briquettes only form 12·3 per cent. of the costs of manufacture.

Of course there are many older briquette factories which in the operation of two presses employ more workers than have been specified in the above list. It remains to be determined whether a larger number of labourers is absolutely necessary under the prevailing special conditions of the plant, or whether a smaller number could be managed with here and there.

In any case, such works have a correspondingly higher wages list which, however, according to the foregoing account, even in an unfavourable case, cannot rise above 0·9 mark per ton of briquettes during the full working of the factory.

With regard to the remaining costs, special attention should be paid to the very moderate amount for repairs and replacements (0·09 mark = 2·1 per cent.), for which the unusually small necessity for repairs in the Couffinhal presses and heating oven is responsible. Other systems of presses are not so favourable in this respect, and the same is to be said of the superheater.

From the foregoing, the long known fact becomes evident that the economy and revenue of coal briquetting depends in the highest degree on the height of the pitch price and the amount of pitch used, and depends principally on the binding material, as has already been more fully worked out in the discussion (p. 28 *et seq*) in Section II. (see also p. 225).

(*b*) *Total Net Costs.*—In addition, the following must be reckoned with the net working costs :—

7. The salaries of the staff of the briquette factory, and

8. The portion falling to the factory, of the general costs (administration, management, other taxes and charges, and so on) of the whole works to which the factory belongs. If the amounts for 7 and 8—reckoned high—are taken together as about 0·5 mark, to which is added 0·08 mark for rounding off, the total net costs of 1-ton briquettes amount to 12·17 + 0·58 = *12·75 marks*.

III. Profit and Revenue.

The standard price (p. 243) fixed by the Rheinisch Westfalischen Kohlensyndicat for 1907–8 amounted to :—

Briquettes I., 13·75 marks per ton
„ II., 13 „ „
„ III., 11·50 „ „

It can be taken from the foregoing list of net costs, with the relatively high prices of coal and pitch and the use of 7 per cent. pitch, that the briquettes produced are of I. quality.

In this case, with

A selling price of . . .	13·75 marks per ton,
A net cost of	12·75 „ „
A profit of	1 mark per ton

will be obtained.

This profit appears to be moderate, but with a yearly production of 30,000 tons always yields a yearly profit of 30,000 marks, equal to about 21 per cent. of the cost of the plant (140,000 marks), which would consequently be paid for in about five years.

With a lower price of pitch, smaller pitch addition, and so on, the profit is correspondingly higher, which is more closely worked out in the following

B. INFLUENCE OF THE COST OF PITCH ON THE PROFIT.

The following table shows how the production of 1 ton of briquettes is taxed with a pitch addition of 5, $5\frac{1}{2}$, 6, and so on up to 10 per cent., and a pitch price of 33, 34, and so on up to 43 marks per ton, and shows the great degree to which briquetting is influenced by the cost of pitch.

With an Addition of, per cent	At a Price of										
	33 M.	34 M.	35 M.	36 M.	37 M.	38 M.	39 M.	40 M.	41 M.	42 M.	43 M.
	M.	M.	M.	M.	M.	M.	M.	M.	M.	M.	M.
5·0	1·65	1·70	1·75	1·80	1·85	1·90	1·95	2·00	2·05	2·10	2·15
5·5	1·815	1·87	1·925	1·98	2·035	2·09	2·145	2·20	2·255	2·31	2·365
6·0	1·98	2·04	2·10	2·16	2·22	2·28	2·34	2·40	2·46	2·52	2·58
6·5	2·145	2·21	2·275	2·34	2·405	2·47	2·535	2·60	2·665	2·73	2·795
7·0	2·31	2·38	2·45	2·52	2·59	2·66	2·73	2·80	2·87	2·94	3·01
7·5	2·475	2·55	2·625	2·70	2·775	2·85	2·925	3·00	3·075	3·15	3·225
8·0	2·64	2·72	2·80	2·88	2·96	3·04	3·12	3·20	3·28	3·36	3·14
8·5	2·805	2·89	2·975	3·06	3·145	3·23	3·315	3·40	3·485	3·57	3·655
9·0	2·97	3·06	3·15	3·24	3·33	3·42	3·51	3·60	3·69	3·78	3·87
9·5	3·135	3·23	3·325	3·42	3·515	3·61	3·705	3·80	3·895	3·99	4·085
10·0	3·30	3·40	3·50	3·60	3·70	3·80	3·90	4·00	4·10	4·20	4·30

Unusually high pitch prices obviously make the profit questionable. In order that the work shall not altogether be without profit or dis-

continued, in such times it is customary to assist matters by reducing the amount of pitch added, and in extreme cases to carry this so far that still serviceable, if not such high-quality, briquettes can be prepared. Under certain conditions a portion of the pitch is replaced by resin (p. 41). But usually the question resolves itself into choosing that smaller pitch addition which can prevent a considerable increase in the pitch costs per ton of briquettes. The table provides a rapid method of deciding this point. To maintain the pitch costs at 2·8 marks per ton of briquettes, the additions and corresponding prices of pitch must be:—8·5 per cent. at 33 marks, 8·0 per cent. at 35 marks, 7·0 per cent. at 40 marks, and so on.

C. ATTAINMENT OF LARGER PROFITS.

Firstly comes the consideration of a diminution in the price of pitch. If, for example, the price of pitch falls from 40 marks to 35 marks per ton, the pitch costs per ton of briquettes, assuming the same 7 per cent addition in both cases, abate from 2·80 marks to 2·45 marks, and consequently the costs of manufacture of 4·22 marks (p 223) (if the whole of the remaining costs are unchanged) are reduced by 0·35 mark to 3·87 marks. Then, assuming the same price for the briquettes, the profit is increased to 1·35 marks per ton and to 40,500 marks per annum.

Since, however, even with a very low standard for the price of pitch it still remains a very expensive binding material, continual consideration must be given to the problem of diminishing the amount of pitch used by improving the methods of manufacture without injuring the quality of the briquettes.

By diminishing the addition of pitch from 7 per cent. to $6\frac{2}{3}$ per cent., for example, only 1998 tons would be required in a year in the above example, and at a pitch price of 35 marks, 2·33 marks per ton would be paid away for pitch, so that, other conditions remaining equal, the costs of manufacture would fall by $2·80 - 2·33 = 0·47$ marks to 3·75 marks, and the profit would increase to 1·47 marks per ton and to 44,100 marks per annum. Consequently, a diminution in the addition of pitch of only $\frac{1}{3}$ per cent. has resulted in an increase of the profit by 44,100 less 40,500 marks, equal to 3600 marks per year

Further economies in the costs of manufacture can be obtained under certain conditions in the costs of the plant relating to paying of interest and liquidation—namely, by abandoning a special boiler plant by, under

certain circumstances, the application of a superheater instead of a heating oven, further, in the coal used in firing, and in the wages bill, by attaching the briquette factory to an existing central electric station; and, above all, by increasing the output of the factory, which has already been brought forward at the beginning of this section (p. 221) and dealt with briefly.

The general solution, therefore, lies in the direction of building larger plants capable of greater outputs, or of increasing the outputs of smaller plants by the erection of further presses. Usually the latter plan offers no difficulties, if only sufficient room exists.

The mechanical appliances for conveyance, crushing, supply, mixing, and distributing are generally already made of such a size by the engineering companies that they can serve more presses than they were originally intended for, and it only becomes necessary to increase their speed. The same applies to the heating ovens or the large steam kneaders with superheater. A heating oven with a table of 6·5 metres, can provide, instead of two, three or even four presses, which can be seen from figs. 23, 24, and 89, showing the briquetting plant of the Zeche Hagenbeck. There three heating ovens of equal size work with eight Couffinhal presses in such a way that the two outside ovens each provide two, while the inner oven provides three, presses with briquetting material. The capacity of output of this plant amounts to about 120,000 tons of briquettes per year.

According to a table of statistics given below in the following Section XI., nine mining companies, excluding the Dahlhausen briquette works, in the district of the Dortmund Mining Commission each showed a briquette production of over 100,000 tons in the year 1907. Of them the Zeche Engelsburg produced over 200,000 tons, and the Zeche Herkules over 300,000 tons.

In general the total net costs—including the due portion of the general costs—for briquette works with modern appliances and capable of large outputs can be made so favourable that, assuming the price of pitch is not too high, profits of about 1·50 to 3·00 marks per ton of briquettes can be made easily.

D. ECONOMICAL CONDITIONS AT THE KÖNIGSGRUBE O.-S. BRIQUETTE FACTORY.

This new briquette factory, built in 1906–7, and described in the previous section (p 204 *et seq.*), the cost of installation of which amounted to

For the building	. .	160,000 marks,
For the internal appliances	. .	180,000 ,,
Total	. .	340,000 marks,

will produce, after the installation of the third press provided for is in full operation, a yearly output of over 100,000 tons, since the three large Tigler system toggle-joint presses are able to produce a total of about 400 tons per day, or 120,000 tons of large briquettes per year. With such an annual production the interest and liquidation of the costs of the plant (10 per cent) work out at 34,000 marks =0 29 mark per ton of briquettes, which is 0 17 mark less than in the case of the above two-press factory with a yearly output of 30,000 tons (0 46 M). The working wages at the Konigsgrube plant are also considerably more favourable, a fact partly attributable to the lower rates of pay.

According to the account of the staff of attendants and wages given on p. 209, the amount paid in wages during the operation of the three presses is about 83·15 marks per day, which, with a daily output of 400 tons, is only about 0·21 mark per ton as against 0 52 mark in the above two-press factory. In this account the wages of the stoker are not considered, since the plant mentioned obtains its steam from the colliery boilers With a corresponding portion of the stoker's wages, the workers' wages per ton of briquettes amount to about 0 30 mark, equal therefore to 0·52 – 0 30 = 0 22 mark lower Whether in the remaining working costs (apart from the pitch used), the cost of the working materials, repairs, and replacements, lower amounts will also be exhibited, is questionable, the time is too short to decide this point As regards pitch, 6 7 per cent is the maximum used for the local coals, and in the costs for pitch at the favourable price of 34 marks only 2 28 marks is paid out, which is 2·80 – 2 28 = 0 52 marks less than in the first example

To this is to be added the considerably lower selling price of the Konigsgrube briquetting coal (coal-dust), which, in the summer of 1908 was 5·50 marks, and only taxed a ton of briquettes to the extent of 5 13 marks as against 7·95 marks

From the foregoing it appears that the conditions of the two briquet-

ting plants—without regarding the costs of working materials, repairs, and replacements—during full working are somewhat as follows:—

Expenditure for	Two press Plant taken for a Yearly Output of 30,000 tons	Kongsgrube Three press Plant for a Yearly Output of 120,000 tons
	Costs per ton of Briquettes	Costs per ton of Briquettes
	M.	M.
1. Interest and liquidation of the cost of the plant	0·46	0·2[illegible]
2. Pitch .	2·80	2·28
3. Wages	0·52	0·[illegible]0
Total .	3·78	2·87
In addition Briquetting coal . . .	7·95	5·13
Total . .	11·73[1]	8·00[1]

According to this there is a difference of almost 1 mark for the three main parts of the costs of manufacture, and taking into account the costs of the briquetting coal there is a difference of 11·73 − 8·00 = 3·73 marks per ton of briquettes in favour of the Kongsgrube plant. On the other hand, the selling price of the Konigsgrube briquettes is lower, being 12·50 marks per ton against 13·75 marks per ton in the first case, which is 1·25 marks lower. If this deficiency be subtracted from the above 3·73 marks, there is still left the very considerable advantage of 2·48 marks for the larger plant, caused by considerably higher output, lower wages, lower pitch prices and the use of a smaller quantity, very much lower cost of the coal briquetted, and the relatively high selling price of the briquettes. Even if it is freely admitted that the remaining working costs not taken into account here such as costs of repairs and replacements do fall heavily at the Kongsgrube plant and correspondingly diminish the advantage, it will still be great enough to ensure a better and more economical application of briquetting than in the first-mentioned example.

E. UNFAVOURABLE PROFITS.

On the other hand the profits of smaller works, particularly those operating with drying appliances and presses in constant need of repairs, appear to be much less satisfactory, especially if the plants are not kept continually employed.

[1] To these amounts the costs for working materials, repairs, and replacements must be added, as stated above

For example, a briquette factory equipped originally with a steam table oven and only one press (revolver type), costing about 100,000 marks, produced only 10,228 tons of briquettes valued at 138,980 marks (at 13·6 marks per ton) in the year 1906. The net costs were 13·27 marks per ton, so that the profit was only 3224[1] marks, corresponding to a liquidation of not more than 3·22 per cent. This is such a modest profit that here the economy of briquetting is queried, and it is only done because no sale has been found for the untreated small coal which is used.

Another works, which possesses a steam table oven and two revolver presses, showed, with incomplete working and a yearly output of 12,000 tons, manufacturing costs of 5 to 6 marks per ton, an amount which is not considerably greater than the calculated manufacturing costs given above (p. 223), and may lead to only a moderate profit.

The following are detailed estimates of the costs of installation of two working coal-briquetting factories with somewhat different equipment and output.

F. ESTIMATE OF COSTS OF THE MECHANICAL APPLIANCES OF A COAL-BRIQUETTE FACTORY WITH ZEITZ FIRE-HEATED DRYING DRUM AND TWO MODEL II. ZEITZ REVOLVER PRESSES.

FOR A TOTAL HOURLY OUTPUT OF ABOUT 13 TONS OF FINISHED 1-KG. BRIQUETTES.[2]
(Water content of the coal up to 20 per cent.)

No.	No. of Pieces.	Object	Approx. Weight.	Approx. Cost.
		(a) *Steam Plant*	kg.	M.
		(1) The boiler is already present.		
		(2) A horizontal steam-engine with condenser, 450 mm. cylinder diameter, 700-mm. stroke, 110 revs. per min., initial pressure 8 atms., generating about 125 H.P.		
		Total for (a) . .	14,700	9,900
		(b) *Working Plant.*		
1	1	Supply elevator for the crude coal, with cast steel link chain, iron frame and rails, as well as sheet-iron cover and driving arrangement. Central length about 12·8 metres	3,800	2,450
2	1	Grate sieve of iron bars for the above	250	130
3	1	Combined hopper of about 4·5 cubic meter capacity, with mouthpiece and scraping arrangement . .	380	240

[1] Compare E. Treptow, "Das Brikettieren der Steinkohle im Königreich Sachsen," *Sächs. Jahrbuch*, 1907.

[2] According to the Zeitzer Eisengiesserei und Maschinenbau Aktiengesellschaft, Zeitz, spring 1908.

TABLE F—*continued.*

No	No of Pieces.	Object	Approx Weight.	Appr Cost
			kg.	M
4	1	Coal distributor, 1100 mm diameter, with driving mechanism	1,100	900
5	1	Zeitz patent fire-heated drying drum, 1600 mm diameter inside the drum, with complete oven equipment, bottom blast valve, dust extractor to remove the flue dust as far as possible, as well as pipe lines and driving mechanism	26,000	17,000
6	1	Dry coal elevator, central length 11 metres, otherwise similar to No. 1	3,600	2,350
7	1	Combined hopper of about 16 cubic metre capacity, with mouthpiece and scraper	950	480
8	1	Coal distributor, 1400 mm diameter, with driving mechanism	1,400	900
9	1	Pitch elevator, central length about 9 metres, otherwise similar to No 1	2,700	1,720
10	1	Pitch-breaker with hopper, grate, and worm distributor	1,100	1,250
11	1	Worm mixer about 4 5 metres long	1,700	980
12	1	Disintegrator, 1200 mm exterior diameter, with removable baskets and dust tight cover, and bearings with ring lubrication	3,100	2,450
13	1	Coal pitch elevator, central length about 12 metres, otherwise as No. 1	3,900	2,530
14	1	Combined hopper with mouthpiece and scraper	280	190
15	1	Distributor, 1100 mm. diameter, with driving mechanism	1,100	900
16	1	Worm conveyor, 350 mm diameter, capable of travelling right or left, about 7·5 metres long	2,300	1,400
17	2	Model II., revolver briquette presses of the latest Zeitz construction, with steam kneader, moulds, and stamps for briquettes, each of about 1 kg. weight and an hourly output of about 13 tons. Powerful construction, all parts being of the best and most suitable materials	46,000	35,500
18	2	Band conveyors of wire netting with iron framework, carrying rollers, tension arrangements, gliders, and driving mechanism	2,400	1,750
		Total for (*b*)	102,960	73,120
		(*c*) *Various*		
19	1	Complete transmission arrangements, the belt pulleys constructed in two parts, excepting, however, the driving pulley on the steam-engine fly-wheel and the lighting dynamo	9,200	5,500
20	1	Complete appliances for a steam superheater with thick-walled cast-iron tubes, including both coarse and fine equipment	8,000	2,600
21	..	Complete pipe lines from the superheater to the steam kneader, including the valve arrangements	1,300	1,000
22	..	Various supports, gliders, coverings for channels, and so on	1,500	525
		Total for (*c*)	20,000	9,625

TOTAL

(*a*) Steam Plant	9,900 marks
(*b*) Working Plant	73,120 ,,
(*c*) Various	9,625 ,,
Total sum	92,645 marks

It is understood that the prices are free on rail at Zeitz station (spring 1908).

For the erection of the foregoing manufacturing appliances and parts the firm send out an experienced erector, for whom a sum of fifteen marks for each day's absence from Zeitz, together with travelling expenses to and fro, must be paid. Special arrangements have to be made for oversea work. Sufficient labourers lifting tackle, and tools are to be provided free of cost

Duties, freightage, bricklayers, navvies, carpenters, slaters, tinsmiths, and painters, further driving belts, tube insulation, glazing, lubricating, and cleaning material, the illuminating appliances, the complete steam-power plant with boiler-feed arrangements, as well as the whole of the iron constructional parts, are not included in the supplies.

G. ESTIMATE OF COSTS OF THE MECHANICAL EQUIPMENT OF A COAL-BRIQUETTE FACTORY, WITH STEAM SUPERHEATER AND FOUR MODEL II. SCHÜRING PATENT TOGGLE-JOINT PRESSES.

FOR A TOTAL HOURLY OUTPUT OF 66 TONS 3- TO 4 KG. BRIQUETTES, OR 74 TONS 6- TO 8-KG. BRIQUETTES.[1]

(Moisture content of the coal up to 10 per cent.)

No	No. of Pieces	Object	Approx. Weight	Approx. Cost
		(a) *Steam Plant.*	kg	M.
1	2	Double tube boiler of 10 atms. super pressure, each of 107 sq. metres heating surface, riveted hydraulically, including fine and coarse equipment for internal firing	49,000	15,900
2	1	Duplex feed steam-pump for dealing with 9000 litres of water per hour	600	950
3	2	Injectors, No. 7	100	300
4	1	Horizontal compound steam engine with condenser of 500 750 mm. cylinder diameter and 800 mm stroke, yielding about 320 H.P. at 100 revs. per min., and initial pressure of 10 atms Of the most modern and powerful construction, controlled from a regulator directly affecting a precision sliding piston. Including oil-pumps, lubricators, condenser cocks, anchor plates, and screws as well as one Satz screw key	31,000	21,800
5	1	Protecting rails for fly wheel and main belts of the steam engine	380	170
6	1	Water tank about 8 cubic metres capacity . .	1,250	450
		(Total *a*) . .	82,330	39,570

[1] According to information from the Zeitzer Eisengiesserei und Maschinenbau Aktiengesellschaft, Zeitz, spring 1908.

TABLE G—*continued*

No.	No. of Pieces	Object	Approx. Weight.	Approx. Cost.
		(b) Working Plant	kg.	M.
7	2	Supply elevators, 500 mm. across the buckets, with wrought-iron gusset chain, iron frame with sheet iron cover and falling slides, wrought iron bucket leads and driving gears. Central length about 16 metres	18,600	8,700
8	2	Grids of iron bars for the above	900	410
9	2	Drum sieves with perforated sheet iron plates, 1500 mm. diameter, 3000 mm. long, with bearings and driving gears	3,600	2,200
10	2	Combined hoppers of sheet with Λ slides and reversing valve	1,600	640
11	4	Storage hoppers of sheet iron, 2500 mm. diameter, with conical bottoms, mouthpiece which can be closed, and scraping arrangements, each of about 26 cubic metres capacity	10,400	3,100
12	4	Coal distributing tables, 1700 mm. diameter, with accessories and driving gears	6,600	3,900
13	2	Pitch-breakers, 400 × 250 mm. breadth between jaws, with strong cast iron frame, the breaking jaws being of Coquillen hard cast iron	9,000	3,800
14	2	Pitch elevators, width of buckets 200 mm., central length 10.5 metres, otherwise as No. 7	6,500	3,800
15	2	Disintegrators for pulverising pitch, diameter of baskets 800 mm., with four series of beaters, ring lubricated bearings, dust-tight covers, the whole on a strong base plate	3,600	3,100
16	2	Combined hopper for ground pitch, with mouthpiece which can be closed, and scraping arrangement	950	500
17	2	Pitch-distributing table, 1000 mm. diameter, with accessories and driving gears	2,800	1,700
18	2	Worm conveyors, 450 mm. diameter, with wrought iron worm troughs and bridges, bearings and driving gears. Delivery length about 9 metres	6,400	3,200
19	2	Disintegrators, 1600 mm. outside diameter, with ring lubricated bearings and dust tight cover, the whole on a strong base plate	8,000	5,700
20	2	Coal pitch elevators, width of buckets 500 mm., central length about 16 metres, otherwise as No. 7	18,600	8,700
21	2	Coal hoppers of sheet iron, with mouthpieces which can be closed, and scraping appliance	1,800	800
22	2	Coal distributing tables, 1700 mm. diameter, with accessories and driving gears	3,300	1,950
23	2	Worm conveyors 350 mm. diameter, length conveyed 8.5 metres, otherwise as No. 18	5,200	2,600
24	2	Wrought iron frames for carrying the coal hoppers, distributing tables and worm conveyors, Nos. 21, 22, and 23	5,800	1,500
25	4	Steam kneaders, 1200 mm. diameter, with cast steel mixing wings on a vertical shaft, steam jets with pipe connection, wrought-iron mixing cylinder, cast iron lower support and driving gears	32,000	19,600
26	4	Worm conveyors between the steam kneaders and briquette presses, with cast-iron worm covers and wrought iron worm wings, bevel wheel drive	8,000	4,800
27	4	Toggle-joint briquette presses, Schuring patent, Model II., for a total hourly output of 66 tons 3.4 kg. briquettes, or 71 tons 6.8 kg. briquettes, stable and carefully erected, the levers, links of the knee joint,		

TABLE G—*continued.*

No.	No. of Pieces.	Object.	Approx. Weight.	Approx. Cost.
		as well as the upper and lower cross head, of the best cast steel, the axles and tension bars of forged steel, the press chambers of soft, forged Siemens-Martin steel, and all the remaining parts of the most suitable materials. The press chambers and stamps are arranged so as to be easily changeable for producing briquettes of other sizes	kg. 124,000	M 84,000
28	4	Loading band of wire netting, 800 mm broad, with wrought-iron frame, carrying rollers, tension arrangement, chain drive, and loading slides with counterweight. Central length about 7 metres . . .	12,400	7,200
		Total (*b*) . . .	290,050	171,900
		(*c*) *Various.*		
29	1	Complete transmission with ring lubricated bearings, all the double-belt pulleys, shafts, couplings, bearing brackets and fastening materials	26,000	14,300
30	2	Complete equipment for the steam superheater with system of cast iron tubes, including steam valve, safety-valve, manometer, pyrometer, masonry, and complete grate equipment . . .	20,000	5,800
31		The complete wrought-iron steam-pipes between superheater and the steam kneaders, including steam valves, cocks, and the condenser pipes to the outside of the building	1,800	1,450
32		The complete steam-pipes between boiler, engine, pump, and superheater, including feed pipes, blow-off pipes, but excluding suction and waste water pipes	4,600	3,200
33		Various wrought-iron supports, slides, channel covers, and so on	4,000	1,200
34	1	Travelling crane in the press room, for hand chain drive, 9 metre span, 5000 kg. carrying power, excluding track along the walls of the building . .	2,800	1,600
35		For erection and setting the foregoing machines and appliances in working order by two or three erectors and one engineer, to whom the necessary helpers, such as locksmiths, blacksmiths, labourers, and so on, as well as sufficient lifting appliances and tools, must be lent free of charge .	.	19,000
		Total for (*c*) . . .	59,200	46,550
		GRAND TOTAL.		
	...	(*a*) Steam Plant . . 39,570 marks (*b*) Working Plant . . . . 171,900 ,, (*c*) Various . . . . . . 46,550 ,,		
		Total . . . 258,020 marks		

The prices are understood to be free on rail at Zeitz station (spring 1908).

SECTION XI.

COAL-BRIQUETTING STATISTICS OF THE MOST IMPORTANT BRIQUETTE-PRODUCING COUNTRIES.

THE most important of these countries at the present are the German Empire, Belgium, France, Great Britain and Ireland, Austria-Hungary,

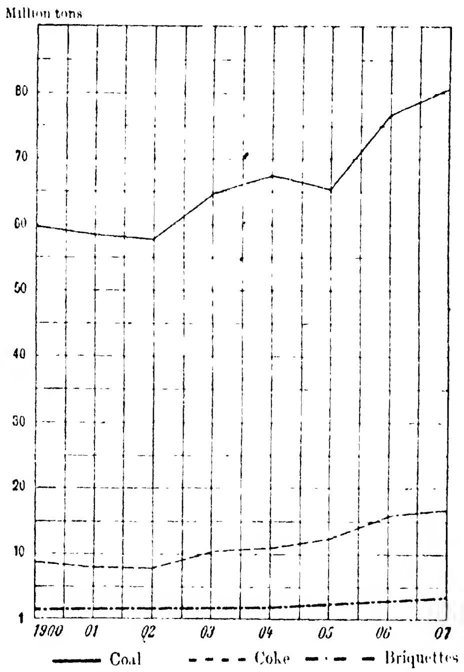

FIG. 104.—Curves representing the development of the coal, coke, and briquette production in the Dortmund Mining Commission's region in the years 1900-1907.

and the United States of North America, in which order they are dealt with in the following pages with the exception of Austria-Hungary, which is dealt with second in consequence of its geographical situation In the statistical tables the coal and coke production of the countries and districts concerned is introduced for the sake of comparison.

A. GERMAN EMPIRE.

The coal-briquette production of Germany is made up mainly of that of Prussia (I.), that of the Upper Rhine district (II.) (so called by the author), and that of the kingdom of Saxony.

I. PRUSSIA

The coal-briquette production of Prussia is made up for the greatest part of that of Lower Rhenish Westphalia (*a*), which in this case is covered by the Dortmund Mining Commission's district. In addition, the remaining districts, Aachen (*b*), Saarbrucken (*c*), Upper Silesia (*d*), and Lower Silesia (*e*), are situated more or less close by. Further, coal briquettes are produced at several distributed points on the coast; the quantities are unknown, but in any case are not specially great and are not considered here.

(*a*) *Lower Rhenish Westphalia (Dortmund Mining Commission's Region)*[1]

Year	Coal obtained.	Coke produced	Briquette Production	No. of Briquette Presses
	tons.	tons.	tons	
1885	28,970,233	2,311,618	98,835	...
1886	28,497,314	2,557,013	128,906	
1887	30,150,328	2,722,616	225,531	...
1888	34,233,614	3,077,067	296,089	.
1889	33,855,110	3,313,009	336,680	.
1890	35,169,290	3,727,075	346,710	..
1891	37,402,191	3,845,086	452,809	
1892	36,853,502	4,177,932	539,256	
1893	38,613,146	4,352,656	720,890	...
1894	40,613,073	4,802,331	751,676	
1895	41,145,744	4,996,731	785,253	
1896	41,893,304	5,767,251	840,320	
1897	48,423,987	6,355,617	961,311	
1898	51,001,551	6,954,365	1,081,931	...
1899	54,611,120	7,708,591	1,318,822	85
1900	59,618,900	8,809,864	1,571,839	97
1901	58,447,657	7,969,825	1,649,918	108
1902	58,038,591	8,062,111	1,655,796	131
1903	64,689,591	10,153,497	1,827,195	142
1904	67,533,681	10,831,437	1,889,087	158
1905[2]	65,373,531	12,097,861	2,256,118	160
1906	76,811,054	15,555,786	2,688,918	163
1907	80,422,746[3]	16,603,621[3]	3,013,095	

It can be seen from the above table and the curves in fig. 104 how extraordinarily steadily the production of briquettes in this greatest

[1] According to the annual reports on "Die Bergwerksindustrie und Bergverwaltung Preuszens" in the *Preuss. Ministerial Zeitschrift*.

[2] Strike year. [3] Provisional figures.

industrial district of Prussia and the German kingdom has developed since 1885 to its present supreme importance. The following table

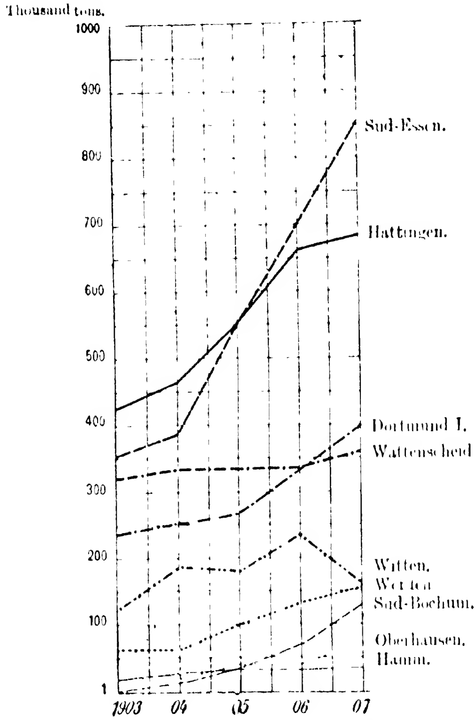

FIG. 105.—Curves showing the development of the briquetting industry in the districts concerned, of the Dortmund Mining Commission's district, in the years 1903–1907.

and the curves in fig. 105 show the production of briquettes in the various mining districts concerned of the Dortmund Mining Commission's district in the years 1903 to 1907 :—[1]

Mining District	1903.	1904.	1905.	1906.	1907.
	tons	tons.	tons	tons	tons.
Hamm	20,601	25,349	31,924	31,146	31,667
Dortmund I.	211,375	253,716	264,346	321,359	399,880
Witten	121,981	188,683	179,439	203,671	151,978
Hattingen . . .	429,591	166,026	558,039	665,770	685,474
Sud Bochum .	4,179	15,220	36,298	70,351	131,842
Wattenscheid . . .	319,396	330,387	329,369	325,461	351,885
Sud Essen	357,664	385,742	553,822	696,219	850,801
Werden	69,302	65,607	99,317	134,272	155,072
Oberhausen . . .		20,166	39,797	46,894	72,332
Total for the Dortmund Mining Commission's district . .	1,567,089	1,751,196	2,092,351	2,495,149	2,838,931

[1] Dr E. Jungt, *Die Bergwerksproduction des Oberbergamtsbezirks Dortmund in den Jahren* 1903–1907, Gluckauf, 1908, No. 11, p. 392.

Briquettes were therefore only produced in 9 (of the total 19) districts, since, as a matter of fact, only the smalls from the smithy and hard coals as they occur, chiefly in the south of the district, are really applicable. In the year 1907, 39 out of the 156 mining commissions in the district possessed briquette factories, and altogether they produced 2,838,931 tons of briquettes, so that the briquette production of the district, assuming an 8 per cent. addition of pitch, is equal to 2,611,817 tons of coal, or 3·6 per cent. of the total coal output (80,182,647 tons). The Zeche Herkules showed the highest production of briquettes. The following table shows the mining companies who had an output of briquettes exceeding 100,000 tons in the year 1907:—

Name.	Output of Coal.	Production of Briquettes.	Coal used for Briquetting.	Share of the Total Coal Output.
	tons	tons.	tons	per cent.
Herkules	633,979	327,164	300,991	47·84
Engelsburg	477,819	210,946	194,070	40·62
Rosenblumendelle	362,614	174,673	160,699	44·32
Friedl. Nachbar	488,846	167,650	154,330	31·57
Siebenplaneten	321,972	128,183	117,928	36·63
Eintracht Tiefbau	481,715	120,307	110,682	22·98
Dahlhauser Tiefbau	222,384	114,990	105,791	47·57
Joh. Deimelsberg	261,480	113,400	104,328	39·90
Hamburg und Franziska	608,170	104,827	96,441	15·86

To this must still be added the Dahlhausen briquette works, which produced 110,340 tons of briquettes in 1907. The standard yearly figures for most of the mining commissions combined in the Essener Kohlensyndicat since 1904 can be seen from the following table:—

YEARLY FIGURES OF THE MINING COMPANIES WITH BRIQUETTE FACTORIES COMBINED IN THE RHEINISCH-WESTFALISCHEN KOHLENSYNDICAT, GIVING THE TOTAL SALE OF COKE, COAL, AND BRIQUETTES, ACCORDING TO THE POSITION ON THE 1ST JANUARY 1908, AS AGAINST THAT OF THE 1ST JANUARY 1907.[1]

Colliery or Company.	Figures for					
	Coal.		Coke.		Briquettes.	
	1907	1908.	1907.	1908.	1907.	1908.
	tons	tons	tons	tons.	tons	tons
Altendorf, Gewerkschaft der Zeche	240,000	240,000		...	72,600	77,300
Aplerbecke Akt.-Verein f. Bergbau Zeche Margarete	300,000	300,000	.	..	90,450	92,450
Blankenburg Gewerkschaft	155,000	155,000	...	..	100,000	100,000
Bochumer Verein f. Bergbau und Guszstahlfabrikation, incl. Gewerksch. ver Engelsburg	361,000	361,000	1,000	4,000	153,000	151,100
Karoline Gewerkschaft	150,000	150,000	...	...	36,300	46,300
Deutsch Luxemburgische Bergwerks und Hutten Aktien-Gesellschaft	1,785,000	1,785,000	128,000	128,000	216,000	246,000
Eintracht Tiefbau Gewerkschaft der Zeche	582,000	582,000	79,000	79,000	163,350	163,350
Essener Steinkohlen bergwerke Akt.-Ges[2]	1,355,000	1,355,000	.	..	160,900	601,700
Ewald, Gewerkschaft des Steinkohlen bergwerks	1,993,000	1,993,000	...	...	51,450	54,450
Frohliche Moyensonne Gewerkschaft	570,000	570,000	142,000	112,000	180,000	180,000
Gelsenkirchener Bergw. Akt.-Ges.	7,698,000	8,698,000	1,404,658	1,726,808	72,600	144,600
Gottessegen, Gewerkschaft des Steink. Bergw.	180,000	180,000	...	...	54,150	54,450
Gutehoffnungshutte Akt. f. Bergbau u. Huttenbetrieb.	1,900,000	1,900,000	40,000	10,000	.	72,000
Harpener Bergbau Akt.-Ges.	7,240,000	7,240,000	1,650,000	1,650,000	17,520	57,620
Hibernia Bergwerks Ges.	5,416,000	5,416,000	812,800	812,800	54,450	54,450
Horder Bergwerks und Huttenverein	150,000	[3]	..	[3]	..	[3]
Johann Deimelsberg Gewerkschaft	240,000	240,000			108,900	115,900

[1] Gluckauf, Essen, 1907 and 1908

[2] Comprising the earlier individual companies, Herkules, Rheinische Anthrazitkohlenwerke, verein. Portingssiepen, and verein. Dahlhauser Tiefbau

[3] Included in the "Phonix Akt.-Ges. f. Bergbau u. Huttenbetr." figures.

YEARLY FIGURES OF THE MINING COMPANIES WITH BRIQUETTE FACTORIES COMBINED IN THE RHEINISCH-WESTFALISCHEN KOHLENSYNDICAT—*continued.*

Colliery or Company.	Figures for					
	Coal.		Coke.		Briquettes.	
	1907	1908.	1907.	1908	1907.	1908.
	tons.	tons	tons	tons	tons	tons.
Mark Bergbau Akt.-Ges . . .	150,000	150,000	.	.	54,000	54,000
Muhlheimer Bergw.-Verein . . .	1,380,000		95,000		325,000	361,900
Nordstern, Akt.-Ges. Steinkohlen Bergwerk . .	2,740,000	[1]	512,610		71,280	[1]
Phönix, Akt-Ges f. Bergbau u. Huttenbetrieb . . .	300,000	3.190,000		512,610		71 280
Siebenplaneten, Gewerksch .	300,000	300,000	61,200	64,600	132,600	132,600
Schalker, Gruben und Huttenver. Akt-Ges.	1,000,000	[2]	222,150	[2]		[2]
Schurbank u Charlottenburg Gewerksch.	180,000	180,000			72,600	72,600
Viktoria, Gewerkschaft	135,000	135,000		.	51,150	54,150
Wiendahlsbank Gewerkschaft .	125,463	125,463		..	54,150	67,950
Briquettwerk Dahlhausen . . .		..			180,000	180,000
Other companies, mining companies not producing briquettes						
Total . .	76,425,834	76,676,157	13,086,993	14,112,850	2,839,910	3,212,810

In the years 1891 to 1903 almost the whole of the briquette-producing works of this district were combined in the Brikettsverkaufsverein zu Dortmund, which attended to the marketing and sale of the output of briquettes, as well as the purchase of the pitch used as binding material, for the whole of the mining companies. The following table is a review of the work of the Brikettsverkaufsverein from 1891 to 1903.

With the end of the year 1903 the Brikettsverkaufsverein zu Dortmund ceased its activity, its sphere of work being then undertaken by the Rheinisch-Westfalischen Kohlensyndicat at Essen. The principal pertinent results obtained during its operation since 1904 are collected together in the following tables.

[1] Included in the "Phönix Akt.-Ges. f. Bergbau u Huttenbetr." figures

[2] Included in the figures relating to the Gelsenkirchener Bergwerks Akt-Ges.

[illegible]MUND (1891 TO 1903)[1] (Compare with the curves in fig 106)

1898	1899	1900	1901.	1902	1903
1,078,338	1,295,113	1,[illegible]0,816	1,563,928	1,610 215	1,780,390
1 066,347	1,215,269	1,185,130	1,519,813	1,046,001	1,691,861
10,901,528 47	13,273,524 56	18,224,501 58	20,265,605 41	18 865,683 16	19,396,320 52
10 39	10 66	12 27	13 33	12 20	11·47
79,757	103,485	108,976	116,956	112,795	116 923
[illegible] 422,265 09	3,593,015 12	4 711,682 42	5,013,210 64	4,622 563 67	6,386 589 71
30 50	32	41	44	41	5[illegible]
31	36	44	42	43	58 50
[illegible]14,879 90	[illegible]07,148 63	272,884 56	204,678 05	656,050 43	1 068,399 71
18 75	15 [illegible]	17 12	12 50	39 55	59 [illegible]9

1902.	1903
1,546,004	1,691,861
85,650	81,440
25,[illegible]77	13,425
2,801	5 [illegible]59
52,886	74,562
9,770	11,035
1,752,968	1,877,282

1902	per cent	1903	per cent
773,258	50 0	726,230	43 0
107,996	7 0	106,924	6 0
463,622	30 0	513,985	30 [illegible]
34,522	2 [illegible]	53,540	3·1
3,425	0 2	3,400	0 2
138 200	8 9	151,872	9·0
24,981	1 7	136,610	8 0
1,546,001	100 0	1,691,861	100 0

[19]04, No. 13)

Review of the Principal Results of the Production and Sale of Briquettes during the Operation of the Rheinisch-Westfälischen Kohlensyndikat for the Years 1904–1907.[1] (Compare with the curves in fig 106)

1. *Use of Briquetting Coal and Pitch.*

	1904	1905.[2]	1906.	1907.
	tons.	tons.	tons.	tons.
Total coal output of the collieries in the syndicate . . .	67,255,901	65,382,522	76,631,431	80,155,994
Amount of the above used for briquetting . . .	1,734,234	1,945,478	2,316,839	2,617,191
= percentage of the output .	=2·58%	=2·98%	=3·02%	=3·26%
The coal used consisted of . —				
(*a*) Small hard coal . .	450,216	410,286	488,041	568,181
= percentage of briquetting coal . . .	=25·96%	=21·09%	=21·06%	=21·71
Approx value per ton .	4·0 M.	4·5 M.	5·0 M	6·75 M
(*b*) Forge coal slack . .	830,332	1,055,252	1,300,139	1,564,279
= percentage of briquetting coal . . .	=47·88%	=54·24%	=56·12%	59·77%
Approx. value per ton .	5·50 M	6·00 M	7·50 M.	8·50 M
(*c*) Small fat coal .	453,656	479,940	528,659	484,728
= percentage of briquetting coal . .	=26·16%	=24·67%	=22·82%	=18·52%
Approx. value per ton	8·75 M.	9·00 M	10·50 M.	11·80 M.
Quantities of pitch used for briquetting[3] . . .	120,153	138,904	161,588	187,586[4]
Total payments for pitch free at the briquette factory (excluding the Syndikatfabrik, Emden)	M 5,666,754·86	M 5,426,431·51	M 6,551,759·12	M. 7,079,956·06
Approx. price of pitch per ton free on waggon at the briquette factory —				
(*a*) At the beginning of the year	50	41	40·50	40·50
(*b*) At the end of the year .	49	38·50	40·50	39·00
Payments for the pitch per ton of briquettes produced .	3·09	2·58	2·62	2·56

2. *Number and Most Important Working Appliances of the Briquette Factories*

	1904.		1905.	1906.	1907
Number of briquette factories	Beginning of the year	31	32	34	36
	End of the year .	31	34	36	38
Factories working with —					
(*a*) Heating ovens . .	Beginning of the year	23	24	26	29
	End of the year .	23	26	28	31
(*b*) Without heating oven but with superheater . .		8	8	8	7
Number of presses (including egg rollers)		137	140	150	156
The presses were .—					
(*a*) Couffinhal presses . .		126	130	138	143
(*b*) Tigler presses . .		3	3	5	6
(*c*) Egg-roller presses . .		7	7	7	7
(*d*) Presses of other construction	Bouriez . . .	1	0	0	0

[1] Based on information supplied by the Kohlensyndicat at Essen.

[2] Strike year.

[3] Almost exclusively medium hard pitch. The quantities of soft pitch used in the fluid state by the Zeche Holland III/IV. from their own coke-tar plant are not included.

[4] Excluding the Niederrheinisch-Westfalischen industrial district.

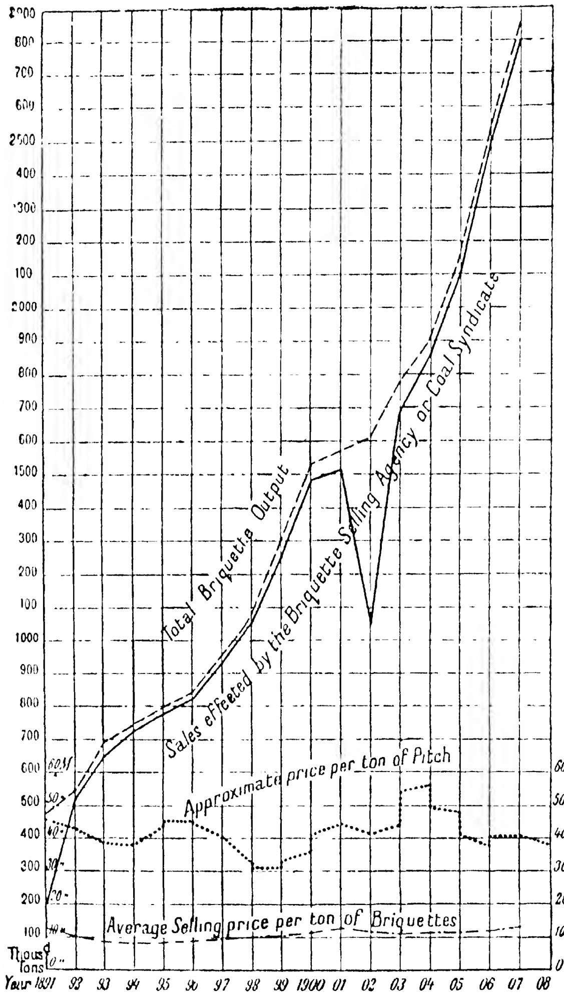

FIG. 106.—Curves of some of the principal results during the operation of the Brikettsverkaufsverein zu Dortmund and the Kohlensyndikats zu Essen.

STATISTICS OF MOST IMPORTANT BRIQUETTE-PRODUCING COUNTRIES.

3. Briquette Production, Sales and Proceeds.

	1904.	1905	1906	1907
	tons.	tons	tons	tons
Total briquette production	1,918,519	2,145,917	2,546,989	2,871,777
Total briquettes sent out including local sales, allowances, and deliveries of the mining companies to their own metallurgical works	1,905,198	2,143,821	2,532,207	2,860,10[illegible]
Sale attributed to the Syndicate, including local sales and sales according to mutual agreement	1,860,587	2,100,480	2,506,918	2,792,39[illegible]
These were made up of—				
(*a*) Complete briquettes	1,798,522	2,037,715	2,426,871	2,703,50[illegible]
percentage of sale	96·66	97·01	96·81	96·82
(*b*) Egg briquettes	62,065	62,765	80,047	88,887
percentage of sale	3·34	2·99	3·19	3·18
Quantities of briquettes sold				
I. Quality	1,012,297	1,009,159	1,373,134	1,886,91[illegible]
II. "	739,872	806,977	992,764	735,12[illegible]
III. "	129,160	100,802	145,169	197,331
	Apr. 1904–5	1905–6	1906–7.	1907–8
Fixed prices for briquettes per ton—	M.	M.	M.	M.
I. Quality		12·50	12·75	13·75
II. "		12	12·25	13
III. "		10·5	10·75	11·5
Average selling price per ton at colliery, of briquettes of all classes	11·73	11·82	11·99	12·61
Total proceeds from the sale of briquettes by the Syndicate at colliery	[illegible]1,082,511·87	[illegible]	29,835,016·40	34,980,460

4. Briquettes used at the Works and Distribution of the Sales.

	1904	1905	1906	1907
Briquettes used at the factories (defective briquettes, breakages, etc.)	tons. 10,432	tons 11,514	tons. 14,556	tons 11,87[illegible]
Of the total quantities of briquettes sold there were sent to				
Local sales and allowances	13,137	16,117	14,896	18,26[illegible]
The metallurgical works attached to collieries	11,611	43,342	20,839	40,14[illegible]
	Apr. 1904–5.	1905–6	1906–7	
German railways	852,468	1,068,159	1,001,317	.
Merchants	700,808	1,003,164	1,222,732	
Works, private sales, etc.	242,860	221,096	139,052	
Canal construction	6,305	5,895	8,927	.
German colonies	14,255	16,570	2,145	...
Oversea transport	94,360	98,222	71,275	

The distribution of the sale of briquettes among the various markets (provinces, countries) is shown by the review collected from official sources and reproduced in the folding table opposite.

(*b*) *Aachen District.*

Year.	Coal Output.	Coke produced.	Total Briquette Production.	These consisted of: Briquettes of 1 and 10 kg. Laurweg Pit.	Briquettes of 3 kg. Maria Pit.	Briquettes, Egg. Laurweg Pit.	Selling Price per ton: 3-kg. Briquettes.	Egg Briquettes.
	tons.	tons.	tons.	tons.	tons.	tons	M	M.
1880	1,194,115	...	22,630	22,630	..	.		...
1885	1,308,723	118,677	14,208	14,208		.	.	
1890	...	..	15,340	13,220		2,120	.	...
1895	1,733,125	211,060	24,500	...	22,750	1,810	11·16	11·25
1900	1,771,489	266,753	17,398		14,750	2,648	.	
1901	1,892,998	...	39,113	...	35,490	3,623	..	..
1902	1,992,076	...	47,230	...	41,870	5,360	.	..
1903	2,165,439	317,255	62,390	...	56,920	5,470	..	...
1904	2,218,450	360,284	67,879	..	62,930	4,949	.	...
1905	2,250,187	371,160	68,934	...	61,750	7,184		.
1906	2,250,583	476,462	66,077	...	57,140	8,937	...	
1907	...	...	68,915	..	55,970	12,945	13·89	11·89

More information with regard to these two briquette factories individually is given in the table on p. 245.

1. Briquette factory at the Laurweg pit at Kohlscheid, formerly in the possession of the "Vereinigungsgesellschaft fur Steinkohlenbau im Wurmrevier," but for some years belonging with other pits to the "Eschweiler Bergwerksverein."

The production of briquettes from flaming or semi-fat coals (containing 13 to 14 per cent volatile constituents) was commenced at this works towards the middle of 1870 with a Middleton-Détombay toggle-lever press by A. Détombay of Marcinelle, near Charleroi, and an egg-roll press by Zimmermann & Hanrez of Monceau-sur-Sambre. This old briquette factory was pulled down after over twenty years working, and was replaced by a new factory for the production of egg briquettes by means of two electrically driven egg-roll presses.

Application of Egg Briquettes.—As domestic fuels, especially as a substitute for the costly anthracite coals for burning in slow combustion stoves of American and other similar systems.

Their Market.—Outside their own limited district egg briquettes are sold, especially in Wurtemburg, Baden, and Hannover-Brunswick.

DISTRIBUTION OF THE

No.	Market	1885		189
		tons	per cent	tons
1	Rhenish Westphalia	18,090	18.19	118,162
2	Hanover, Brunswick	10,924 inclusive of amounts for 7–9	10.92	115,088 inclusive of amounts for 7–9
3	Hessen-Nassau	1,316	1.35	21,874
4	Hamburg, Schleswig-Holstein, Jutland	11,594 inclusive of amount for 10	11.59	[illegible] inclusive of the amounts for 10
5	Bremen, Oldenburg, East Frisia			
6	Bavaria, Baden, Wurtemberg	206	0.21	21,865
7	Saxony Province	included in the total of 2		included in the total of 2
8	Thuringia and Kingdom of Saxony			
9	Berlin and Brandenburg Province			
10	Pomerania, Lubeck, Mecklenburg, and the Danish Islands	included in 4–5		included in 4–5
11	Alsace-Lorraine	110	0.11	50
	I. Interior of Germany[1]	78,279	78.28	334,004
12	Holland	10,527	10.53	8,580
13	Belgium and Luxembourg	280	0.28	210
14	France			
15	Switzerland	2,550	2.25	1,510
16	Austria and Italy	1,530	1.53	290
17	England and Sweden			
18	Spain, Roumania, and Greece			
19	Russia			
20	States outside Europe	6,830	6.83	5,030
	II. External	21,717	21.72	18,150
	Total sum (I. and II.)	99,996	100.00	351,154

[1] According to the annual r

'MUND TO THE VARIOUS MARKETS

1902		1903		1904		1905		1906	
s	per cent	tons	per cent	tons	per cent	tons	per cent	tons	per cent
679	46·8	921,606	51·1	853,116	46·4	1,057,144	49·0	1,213,363	47·5
913	9·2	159,581	8·8	165,316	9·0	202,685	9·6	235,654	9·2
950	6·3	108,351	6·0	179,188	9·8	213,560	9·9	221,949	8·7
315	6·2	94,051	5·2	85,825	4·7	96,419	4·2	73,472	2·7
757	4·3	85,950	4·7	62,031	3·4	65,452	2·9	74,305	2·9
508	3·4	42,783	2·4	41,089	2·2	48,904	2·3	57,820	2·3
693	8·2	128,940	7·1	134,783	7·3	148,412	6·9	180,599	7·1
480	5·9	87,560	4·9	93,899	5·1	75,981	3·5	109,782	4·3
532	0·7	23,100	1·3	32,187	1·7	33,652	1·6	47,201	1·8
,785	0·7	19,627	1·1	13,923	0·8	7,890	0·4	10,772	0·4
655	0·6	8,110	0·5	10,877	0·6	6,997	0·3	10,855	0·4
467	92·0	1,677,881	93·0	1,672,347	91·0	1,953,976	90·6	2,235,772	87·6
[illegible]	2·6	40,440	2·2	55,641	3·0	58,721	2·7	76,429	3·0
151	1·0	27,210	1·5	32,832	1·8	74,805	3·5	136,705	5·4
555	0·0	1,850	0·1	7,422	0·4	2,047	0·1	16,876	0·7
520	3·7	39,891	2·2	28,368	1·6	23,515	1·1	44,257	1·7
,266	0·4	12,385	0·7	31,201	1·7	29,882	1·4	27,318	1·1
					...				
150	0·0					..			
	...			..				...	
,650	0·3	3,400	0·2	9,827	0·5	12,900	0·6	15,500	0·6
,013	8·0	125,176	6·9	165,291	9·0	204,870	9·4	317,115	12·4
480	100·0	1,803,057	100·0	1,837,538	100·0	2,256,118	100·0	2,552,887	100·0

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QUETTE SALES OF THE OBERBERGAMTSBEZIR

	1895		1900.		1901.	
per cent.	tons	per cent.	tons	per cent	tons	per
33·70	337,538	42·83	777,950	50·61	729,180	1
32·71	205,868 inclusive of amounts for 7–9	26·12	159,331	10·37	159,182	1
6·23	39,369	5·01	81,111	5·30	81,979	
15·84	155,510 inclusive of the amounts for 10	19·73	81,459	5·30	95,068	
			48,137	3·13	51,320	
6·23	22,151	2·85	46,628	3·03	58,239	
	included in the total of 2		139,550	9·08	151,841	
			78,187	5·09	92,132	
			10,235	0·66	10,129	
	included in 1–5		11,136	0·71	10,965	
0·01	300	0·01	15,767	1·25	9,137	
94·75	761,036	96·58	1,450,091	94·11	1,458,752	
2·38	16,486	2·09	19,833	1·29	26,402	
0·06	10	0·00	2,320	0·15	13,670	
	...	..	10	0·00	30	
1·30	7,937	1·01	59,814	3·89	74,861	
0·08	2,560	0·32	3,616	0·23	1,597	
..	.		.	...		
		...		...	.	
		.			10	
1·43		..	150	0·05	2,200	
5·25	26,993	3·12	86,013	5·59	118,770	
100·00	788,029	100·00	1,536,131	100·00	1,577,522	10

orts on "die Bergwerksindustrie und Bergverwaltung Preuszens," publ

WORKING RELATIONS OF THE BRIQUETTE FACTORIES IN THE YEAR 1907.

	Number of		Machines in Operation.				Number of Workers			Total amount of Wages per Shift.		
	Briquette Factories.	Presses and Systems of Presses.	Steam-Engine. No.	Steam-Engine. H.P.	Electric Motors. No.	Electric Motors. H.P.	On Contract.	On Daily Wages.	Total.	Contract Wages.	Shift Wages.	Total.
										M.	M.	M.
Laurweg pit	1	2 egg roll presses			2	55 + 10 } 65		5	5	...	18·40	18·40
Maria pit	1	4 Couffinhal presses	1	100	1	7½	31	9	40	118·11	29·20	147·31
			For the working of only two presses, however.				19	6	25	67	20·60	87·60

2. Briquette factory at the Maria pit, Hongen. The ownership relations are the same as for No. 1.

Built by Schüchtermann & Kremer of Dortmund, and put into operation in 1905, this factory contains two systems, each consisting of a heating oven and two Couffinhal presses, and produces 3-kg. briquettes from semi-fat coals. The factory is operated by a steam-engine of 100 H.P., and an electric motor of 7½ H.P. to drive the elevator. Outside the small district, in which the briquettes are used specially for paper factories, glass-works, for firing locomotives and steam rollers, the market for these briquettes is to be found principally in Switzerland and Bavaria, where they are used on mine railways, steamships, breweries, and so on.

(c) *Saarbrücken District.*

In the Saarbrucken district the briquetting of coal is still new and quite unimportant. This is mainly due to the fact that the small flaming and fat coals (small nuts and slack), when they are not used at the colliery, are almost wholly employed for direct firing in iron-works, glass-works, etc., or for coking purposes.

In the whole district there is only one briquette factory, and that is the State briquetting plant at Hafemont Malstatt near Saarbrücken. Equipped by Schüchtermann & Kremer with one Couffinhal press and heating oven, the plant came into operation in the year 1904 and produces principally 6-kg. briquettes. Up to the present, however, it has been used very little (for about one month in the year), as the following table will show. The supply of small coal for briquetting often fails, and the orders for briquettes are very few.

OUTPUT OF COAL, COKE, AND BRIQUETTES IN THE DISTRICT OF THE KGL. BERGWERKSDIREKTION, SAARBRÜCKEN (1904–1907)[1]

Year.	Coal Output	Coke produced.[2]	Briquette Production
	tons	tons.	tons.
1904	10,364,777	1,129,061	1,936
1905	10,619,120	1,156,831	8,587
1906	11,140,121	1,164,539	7,057
1907	10,693,313	1,129,282	3,029

The briquettes are sold principally in the interior of Prussia Alsace Lorraine, South Germany, and Switzerland

(d) *Upper Silesia.*

In this, the second largest coal-producing district of Prussian Germany, briquetting has developed continuously since its inception in the year 1893, but has never reached large dimensions, principally because the Upper Silesian zinc-works, in combination with the iron-works, have claimed by far the greatest part of the flaming and forge coals. These conditions do not promise to change very much in the immediate future (On the following page are two tables which show the briquette production and conditions of working) The following is reported of the individual briquette factories –

1. The Emma pit briquette factory (Rybniker Steinkohlengewerkschaft), Rybnik district, Upper Silesia,[3] commenced work in 1893, and has been extended from time to time Since 1905 it has worked with four Couffinhal presses with heating ovens (Schuchtermann & Kremer) and three Yeadon-Busse presses (Zeitzer Eisengieszerei und Maschinenbau Aktiengesellschaft) The amount of pitch (hard and soft) is on the average 9 per cent of the briquetting mixture

One steam-engine of 145 H P. and one electric motor of 110 H P supply the motive power. Seventy-five workmen are employed. Briquettes of 3 kg, but mostly of 1 kg weight, are produced

1893	7,124·95 tons	1905	60,755·00 tons
1895	12,341·05 ,,	1906	60,858·00 ,,
1900	25,985·20 ,,	1907	63,334·60 ,,

[1] According to the reports on "Die Bergwerksindustrie und Bergverwaltung Preuszens," published in the *Preus., Zeitschr. fur Berg- H.- und S.-W.*

[2] By the State and private coking plants.

[3] According to the report of the works management.

The briquettes are sold partly to railway companies and partly privately. Considerable quantities of the 1-kg briquettes are sent among other places, to East Prussia, where they are much in demand as domestic fuels for banking fires

Year	Coal Output	Production of Coke and Cinder	Production of Briquettes.	
			Tons	Total Value Marks
	tons	tons		
1895		.	189,928	
1900	24,815,041	1,411,625	100,105	.
1901	25,251,6[illegible]5	1,257,113	116 059	
1902	24,470,788	1,772 487	131 561	
1903	25 235,649	1,241,[illegible]48	126,279	
1904	25,126,493	1,388,955	135,221	1,350,000[1]
1905	27,003,120	1,166,339	143 065	1 430,000
1906	29,653,5[illegible]8	1,568,068	138,818	1 388,899
1907	3[illegible] 221,271	1,617,350	143,995	1,531,623

WORKING CONDITIONS OF THE BRIQUETTE FACTORY

Year	Number of Briquette Factories	Power Machines					Number of Workers				Wages Paid to Workers				
		Presses	Steam Engines		Electric Motors		Males		Females	Total.	Males		Females	Total.	[illegible]
			No.	H.P	No	H P.	Over 16 Years	Under 16 Years.			Over 16 Years	Under 16 Years			
											M.	M	M	M	
1904	2	9	3	280	3	66	154	5	.	159	123,031	1,800		124,831	[illegible]
1905	2	9	3	280	5	163	177	31	3	211	134,278	13,991	845	149,114	[illegible]
1906	2	11	2	265	6	253	115	39		154	111,299	17,879		129,173	[illegible]
1907	2, + 1 in course of erection.	13	2	265	7	543	117	41		158	98,201	18,280		116,381	[illegible]

2 Briquette factory of the firm Caesar Wollheim, Berlin, at Zaborze, in the Zabrze district.[2]

The factory commenced work in 1894, is gradually being extended, and has worked since 1903 with four Coutfinhal presses and heating ovens by Schuchtermann & Kremer, and one Yeadon-Busse press by the Zeitzer Eisengieszerei. An egg-roll press obtained from Belgium in 1899 proved unsatisfactory, and was put out of operation. Flaming

[1] According to the *Statistik der Oberschlesischen Berg- und Huttenwerke*, issued annually by the Oberschlesischen Berg- und Huttenmannischen Verein, E V Hattowitz.

[2] From information given by the firm

coal-dust from the neighbouring State Konigin-Luise mine is worked up with pitch from the coking plants of Upper Silesia, the chemical factories of Zabrze, and the Gluckauf coking installation. The pitch used amounted to :—

	per cent		per cent		per cent.
1895	7·58	1900	8·81	1904	8·41
1896	7 72	1901	8·75	1905	8·41
1897	7 71	1902	8·14	1906	8 01
1898	7 90	1903	8 35	1907	8·37
1899	8·03				

Since 1906 the motive power has been supplied by one steam-engine of 120 H.P. and four electric motors of 30, 30, 5, and 60 H P., making a total of 125 H.P.

Year	Number of Workers.			Wages paid to Workers			
	Over 16 Years.	Under 16 Years	Total.	Over 16 Years.	Under 16 Years	Total.	Per ton of Briquettes
				M	M	M	M
1906	54	14	68	65,200	7,100	72,000	0 92
1907	59	16	75	53,690	7,600	61,000	0·76

The labour costs per ton of briquettes have therefore been considerably reduced in the last year

The production of 3-kg. and 1-kg. briquettes amounted to —

Year	Tons.	Value.	
		M.	Per ton.
			M.
1895	36,587	267,600	7·32
1900	74,120	751,000	10·13
1905	82,370	818,700	9 94
1906	78,590	805,400	10 25
1907	80,030	880,500	11·00

The briquettes are for the greatest part used as service coal on the Prussian State Railways.

3. Briquette factory at the State Konigs pit (Königl. Berginspektion I. at Konigshutte).

This latest briquette factory, first set into operation in the spring of 1908 with two Tigler presses is described and illustrated above (see p. 221 *et seq*). The corresponding figures are given in the above description.

(*c*) *Lower Silesia*[1]

Year	Output of Coal.	Coke produced	Briquette Production	Sale of Briquettes				
				Internally	Externally (to Austria)	Total	Value	
							Total	Per Ton
	tons	tons	tons	tons	tons	tons	M	
1903	4,920,180	199,522						
1904	5,225,155	579,254	21,035	18,200	1,021	19,221		
1905	5,301,480	647,722	27,015	24,712	1,349	29,061	312,250	12·12
1906	5,403,056	646,398	54,464	47,594	1,869	52,163	658,110	12 55
1907	5,579,702	780,737	63,757	57,341	5,349	62,690	815,726	13 01

WORKING CONDITIONS OF THE BRIQUETTE FACTORIES

Year	Used for Briquetting			No. of			Power Machines.			
	Coals.		Pitch and other Materials	Briquette Factories	Presses and Systems of Presses		Steam Engines		Electric Motors	
	Tons	Per cent of the Output					No	H.P	No	H P
			tons							
1906	50,5[illegible]3	0·94	4071	2	3	1 Yeadon Busse press 1 Tigler press 1 Coalfinhal press	6	230	3	12
1907	58,540	1 05	5217	2	3	do	4	230	6	193

The two briquette factories are to be found at the following works —

1 Deep working (Hans Heinrich and Marie shaft) at the Furstensteiner mine at Waldenburg[2] (Furstl Pleszische Bergwerks-direktion) This briquette factory was built by the Zeitzer Eisen-gieszerei und Maschinenbau Akt.-Ges. in the year 1903 and commenced working in 1904. Washed coal of 1 to 10 mm. grain size, containing 4 to 5 per cent. ash and about 12 to 14 per cent moisture (selling price in the spring of 1908 about 9 to 10 marks per ton), is dried to about 3

[1] Collected partly from the yearly reports of the "Vereins fur die bergbaulichen Interessen Niederschlesiens."

[2] According to the report of the works management.

to 4 per cent moisture in a steam table drying oven It is then mixed with about 6·5 per cent. pitch and briquetted by means of a Yeadon-Busse press or latterly with the aid of a Tigler press Medium hard pitch with a softening point at 50 to 60 C., from the Upper Silesian coking plants or the chemical works in Zabrze, is employed

The motive power required for driving the whole briquette installation is 89 H.P., for no load, about 35 H.P. Working with only one press, 60 H.P. is sufficient.

The elevator for the crude coal, the drying oven and the pitch-breaker work in common Wages per ton of briquettes amount to almost 90 pfgs.

The quantities of 1-kg briquettes prepared were as follows —

1905	. .	23,765·0 tons	The railway authorities are the principal customers
1906	. .	32,244·5 ,,	
1907	. .	38,905·5 ,,	

2 Kons Melchior pit at Waldenburg (owned by the firm of Kulmiz in Saarau)

The briquette factory was built by Schuchtermann & Kremer of Dortmund, commenced operations in May 1905 works with one heating oven and one Couffinhal press, and produces briquettes each weighing 3 kgs

1905	. . . .	3·252 tons
1906	. . . .	22,522 ,,
1907	. . . .	24,843 ,,

TOTAL OF THE PRUSSIAN COAL BRIQUETTE PRODUCTION IN THE YEARS 1900-1907.

Year.	*a* Lower Rhenish Westphalia	*b* Aachen District	*c* Saarbrucken District	*d* Upper Silesia	*e* Lower Silesia	Total Kingdom of Prussia
	tons.	tons	tons	tons	tons	tons
1900	1,571,839	17,398		100,105		1,689,342
1901	1,649,948	39,115		116,059		1,805,122
1902	1,655,796	47,230		131,565		1,834,591
1903	1,827,195	62,390		126,279		2,015,864
1904	1,888,087	67,879	1936	135,221	24,035	2,118,158
1905	2,256,118	68,931	8587	143,065	27,015	2,503,719
1906	2,688,918	66,077	7057	138,818	54,641	2,955,511
1907	3,043,095	68,915	3029	143,995	63,757	3,322,791

Fuel Requirements of the Prussian Railway Authorities —The following table shows the estimated total requirements of fuel of various descriptions for 1907 according to the budget —

Kind of Fuel.	Weight	Total Cost	Average Price per ton
	tons	M	M
Coal . . .	7,952,400	87,953,700	11.06
Coal briquettes .	1,153,000	14,351,200	12.45
Coke	66,300	1,011,900	15.26
Lignite and briquettes	111,000	943,200	8.49
Total	9,275,800	104,260,000	11.24

The orders for coal briquettes were distributed among the individual districts as follows:

District	Weight	Total Cost	Average Price per ton
	tons	M	M
Westphalian district	953,000	11,817,200	12.40
Upper Silesia ,,	110,000	1,144,000	10.40
Lower ,, ,, .	20,000	242,000	12.10
Other districts .	70,000	1,148,000	16.40
Total .	1,153,000	14,351,200	12.45
	12.43 per cent of the total fuel ordered	13.76 per cent of the total costs of fuel	

II. Upper Rhine District

This district occupies a peculiar position, inasmuch as the whole of the briquette factories belonging to it are situated far away from the areas yielding the coal worked to briquettes; consequently, since they derive the whole of their coal from the Lower Rhenish Westphalian colliery district, it has to be brought up the Rhine from the Ruhr ports to the Upper Rhine ports at Mainz and Mannheim in gigantic coal barges. The briquette production of the works must therefore be included with those of Lower Rhenish Westphalia.

As in the colliery district, hard, smithy, and fat coal smalls are principally briquetted with the addition of pitch, which is also derived from the same source, but small quantities are also obtained from England and Holland. The small coals are mainly slack which has been produced from the coarse kinds of coal originally transported after the subsequent numerous unloadings and deliveries.

Most of the briquette works are laid down by and owned by the

large Lower Rhenish coal-dealers. For the most part, their internal equipment has been carried out by Schuchtermann & Kremer of Dortmund, and consequently Couffinhal presses are mainly used. The Maschinenbau Akt.-Ges Tigler of Duisburg-Meiderich is, however, also represented (Rheinau briquette works and others). So far as can be determined, the briquette production of these works has not up to the present been collected and dealt with in official or unofficial production statistics either of the kingdom or of the individual states concerned.

Further information collected by the author on the Upper Rhine briquette works and their outputs will be seen from the following tables.

An accurate representation of the total coal-briquette production of the Upper Rhine works was not available at this time. If estimated values, based on the producing capacity as well as the conditions of production and sale, are inserted for the works dealt with last and whose actual outputs are unknown, the following round numbers are obtained for the yearly outputs —

	1900.	1901.	1902	1903	1904	1905	1906.	1907
	tons.	tons.	tons.	tons.	tons.	tons.	tons.	tons
Approximate	470,000	415,000	450,000	510,000	400,000	525,000	550,000	630,000

These are very great totals which, with the exception of Lower Rhenish Westphalia, greatly exceed the total yearly productions of the remaining German coal-briquetting districts.

Taking the present average yearly production of the Upper Rhine district as 500,000 tons in round numbers, and an average selling price of the briquettes produced as fifteen marks, an average sale value of about 7,500,000 marks is obtained for the mean yearly production

From this point of view, the briquette statistics of the German Empire, in which, as has already been mentioned above, the briquette works of the Upper Rhine have not been considered up to the present, show considerable deficiencies, and as a result give too low a value for the total coal-briquette production of the empire—a deficiency which should soon be corrected.

The natural principal markets for the briquettes of this district are South Germany and Switzerland. The main users are the railways and industries, while small quantities are also applied as domestic fuels.

UPPER RHINE BRIQUETTE WORKS AND THEIR PRODUCTION OF BRIQUETTES

No.	Name of Works or Firm	Presses				Production of Briquettes							
		No.	Design	For Briquettes of	Year of Installation	1900	1901	1902	1903	1904	1905	1906.	1907
1	Franz Haniel & Co., Duisburg Ruhrort			kg		tons	tons	tons	tons	tons	tons	tons	tons
	(a) Pressed coal works—Mannheim	4	Couffinhal	3	(2–189[illegible]) (2 1894)	[illegible]3,517	4[illegible]4	53,1[illegible]4	6[illegible],933	4[illegible],[illegible]13	60,053	70,3[illegible]4	8[illegible]
2	(b) ,, ,, Gustavsburg near Mainz	—	,,	[illegible]	2–189[illegible]	[illegible]9,737	34,[illegible]13	34,3[illegible]5	37,12[illegible]	24,79[illegible]	[illegible],[illegible]2	21,435	23,3[illegible]
3	Another works in the same district[3]		,,	3	(2—189[illegible]) (1—1903)	70,000	59,000	[illegible]6,000	86,000	77,000	70,000	[illegible],000	9[illegible],000
4	Matthias Stinnes, Mulheim on the Ruhr	—	,		189[illegible]	From 1.4.1900 to 31.3.1901 2[illegible],[illegible]75	From 1.4.1901 to 31.3.1902 52,[illegible]	From 1.4.1902 to 31.3.190[illegible] [illegible]4,47[illegible]	From 1.4.1903 to 31.3.1904 4[illegible]	From 1.4.1904 to 31.3.1905 30,77[illegible]	From 1.4.1905 to 31.3.190[illegible] [illegible],11[illegible]	From 1.4.1906 to 31.3.1907 2[illegible],7[illegible]0	From 1.4.1907 to 31.3.190[illegible] 3[illegible],[illegible]5
	Mannheim briquette works	1	Tigler	10	190[illegible]							3 kg briquettes 3,340	43,465
	For their own use					1,120	1,2[illegible]	1,[illegible]	1,[illegible]5	[illegible],2[illegible]5	2,[illegible]2[illegible]	1 kg briquettes 2,[illegible]7	3,030
5	Harpener Bergbauaktiengesellschaft shipping division, Mulheim on the Ruhr (formerly Bergbau and Schiff-fahrts aktiengesellschaft Kannengieszer) Briquette works in Gustavsburg	4	Couffinhal	5	(2–1892) (2—189[illegible])	About 70,000 tons a year. Exclusively [illegible] for works use							
6	Hugo Stinnes, Mulheim on the Ruhr Strasburg coal preparation Plant at Rheinau baden	([illegible]) 1 [illegible]	—	3 [illegible]1[illegible] [illegible]	1895 189[illegible] 1[illegible]	Capacity of the [illegible] presses [illegible] Working [illegible] about 1[illegible] briquettes per year [illegible]							
7	Anthracite Coal and Coke Works Ges. m. b. H., Dusseldorf Rheinau briquette works	2	Tigler 4 (small model)	[illegible] grms	190[illegible]	Capacity of the Press[illegible] Working [illegible] briquettes per year 3[illegible]							

(In addition to these seven works there is a possible existence of several others.)

[1] The name cannot be given.
[2] According to a prospectus issued by the Maschinenfabrik Schuchtermann & Kremer of Dortmund.
[3] Estimated. The quantity of briquettes actually produced cannot be given exactly.
[4] According to a prospectus issued by the Maschinenbau Aktiengesellschaft Tigler of Duisburg Meiderich.

III. Kingdom of Saxony[1]

Year.	Output of Coal	Production of Coal Briquettes		Number of	
		Tons.	Value per Ton	Briquette Factories	Presses
	tons		M		
1897	1,536,603	3,547	...	3	4
1900	1,862,700	11,600	15·95	3	5
1901	4,683,849	11,596	16·13	3	5
1902	4,107,255	18,185	14·12	5	8
1903	4,150,111	29,691	13·91	6	9
1904	4,175,107	10,206	13·64	6	9
1905	4,913,607	19,643	13·77	6	9
1906	4,812,846	19,129	14·51	6	9

Further information regarding the Saxon coal-briquette works can be obtained from the following table

Data of the Coal Briquette Works of the Kingdom of Saxony[2]

No	Name of Works	Presses		Year of Installation	Briquette Production			
					1905.		1906.	
		No	Design		Tons	Value	Tons	Value
						M		M
1	Zwickauer Steinkohlenbauverein	1	David	1865	6,024	77,747	5,359	71,121
2	Zwickauer Briquette Works	1	David	?		.		
3	Oelsnitzer Briquette Works Glückauf Oscar Förster	3	Yeadon (Königin Marienhütte) Cainsdorf i. S.	1894 1896 1900			13,500	?
4	Steinkohlenwerk Morgenstern in Reinsdorf	1	Yeadon (Königin Marienhütte)	1896	12,530	175,077	12,567	182,120
5	Steinkohlenwerk Bockwa Hohndorf Verein. Feld[3]	1	Yeadon Busse (Zeitzer Eisengiesserei und Masch. Akt. Ges.)	1902	9,838	135,724	10,228	138,980
6	Freiherrlich von Burgker Steinkohlenwerk im Plauenschen Grunde	2 [illegible]	Yeadon-Busse (Zeitzer Eisengiesserei und Masch. Akt.-Ges.)	1902	21,251	294,961	21,275	306,998

[1] According to the various volumes of the *Jahrbuch f. d. Berg- und Hüttenwesen im Königreich*

[2] According to E. Treptow, "Das Brikettieren der Steinkohle im Königreich Sachsen" (above *Jahrbuch* for the year 1907, A, p. 48)

[3] This briquetting plant is described and illustrated in the previously indicated communication.

In the kingdom of Saxony briquettes of 2 or 1 kg. and 700 grm. are principally prepared. The former find application for locomotive firing on the State railways and the 700 grm. briquettes are used as house fuels for the most part.

The briquetting plant mentioned under 6 Freiherrl. v. Burgker is described and illustrated above (p. 197).

SUMMARY OF THE COAL BRIQUETTE PRODUCTION OF THE GERMAN EMPIRE IN THE YEARS 1900 TO 1907

Year	I. Prussia	II. Upper Rhine District (partly estimated)	III. Kingdom of Saxony	Total A. German Empire
	tons briquettes	tons briquettes	tons briquettes	tons briquettes (approx.)
1900	1,689,312	170,000	11,600	2,[illegible]1,000
1901	1,80[illegible],122	115,000	11,[illegible]96	[illegible]
1902	1,8[illegible]4,[illegible]91	150,000	18,18[illegible]	2,30[illegible],700
1903	2,015,864	510,000	29,691	[illegible],500
1904	2,118,158	400,000	40,206	2,[illegible]58,[illegible]00
1905	2,50[illegible],719	525,000	49,613	3,078,300
1906	2,955,[illegible]41	550,000	49,129	3,555,600
1907	3,322,[illegible]91	630,000	50,000 (estimated)	4,003,800

THE EXPORT AND IMPORT OF COAL BRIQUETTES IN THE GERMAN CUSTOMS AREA

Year	Export	Tons	Imports of Foreign Coal Briquettes	Excess of Exports over Imports
			tons	tons
1906		764,840	13[illegible],877	6[illegible]8,963
1907		857,775	156,[illegible]70	701,[illegible]
	Of these there were sent to		Of these there came from	
	Belgium	1[illegible]1,787	110,8[illegible]1	10,9[illegible]6
	Holland	100,346	24,60[illegible]	75,602
	Austria-Hungary	64,580	610	63,970
	Switzerland	12[illegible],78[illegible]	911	569
	France	34,176		
	Denmark	4,742		...
	German S.W. Africa	5,744		

The share of the exports accruing to the Rhenish Westphalia Coal Syndicate amounted to

1906 . 438,191 tons = 57·3 per cent. of the total export
1907 . 510,493 „ = 60·9 „ „ „ „

Since the quite considerable production of the Upper Rhine district has been considered here for the first time in the coal briquette

statistics of the German Empire, considerably higher figures for the yearly output of the whole kingdom have been obtained than have been hitherto reported or assumed. Accordingly, the coal-briquette production of the German Empire, at all events since 1900, takes the first place when compared with that of the other states which come under consideration (see following tables) in later years its production has far exceeded that of these countries

A considerable proportion of the German coal briquettes are exported, and the exports are counteracted by only inconsiderable quantities of imports. The foregoing table gives information on this point for the two years 1906 and 1907.

B. AUSTRIA-HUNGARY MONARCHY

I AUSTRIA [1]

Year	Coal Output	Coke Production	Briquette Production (Pressed Coals, Boulets, and Coal Briquettes)	
			Tons	Money Value
	tons.	tons		kronen.
1900	10,922,545	1,227,918	59,691	
1901	11,738,840	1,275,900	89,950	1,115,885
1902	11,015,039	1,160,846		
1903	11,198,111	1,168,263	122,164	1,570,332
1904	11,868,245	1,282,473	131,776	1,708,918
1905	12,585,263	1,400,283	136,059	1,721,499
1906	13,473,307	1,677,646	142,135	1,820,459

COAL USED AND PROPORTION OF THE PRESSED COAL AND COAL BRIQUETTES OF THE TOTAL BRIQUETTE PRODUCTION.

Year	Coal Dust for Pressed Coals.		Production of Pressed Coals		Coal used for Coal Briquettes.		Coal Briquettes produced	
	Tons.	Value Kronen.	Tons	Value Kronen.	Tons.	Value Kronen.	Tons	Value Kronen.
1905	72,419	732,157	76,800	944,640	55,205	368,589	59,259	776,859
1906	79,367	770,227	78,800	985,000	59,140	389,155	63,335	835,459

The production of briquettes in Austria takes place chiefly in the Mahrisch-Ostrau district.

[1] According to the *Oesterreich Zeitschr. f Berg- u. Huttenwesen.*

II Hungary[1]

Year.	Coal Output Tons	Coke produced Tons	Briquettes produced Tons	Value Kronen	Value Kronen per ton
1900	1,367,190	12,973	69,[illegible]		
1901	1,351,916	10,975	40 182		
1902	1,098,297	8,201	88,069	1 293,000	14 7
1903	1,170 390	9,442	101,197	1,448,000	14 3
1904	1,155,320	5,103	103,481	1 168,000	11 2
1905	1,088,087	69,303	144,697	2,165,000	14 9[illegible]
1906					

Tata and Funfkirchen are the principal places in which briquettes are produced

Accordingly, the production for the monarchy of Austria Hungary is —

Year	I Austria	II Hungary	Total B
	tons	tons	tons
1904	134,776	103 481	238,257
1905	133,059	144,697	280,756
1906	142,1[illegible]		about 300,000

C BELGIUM.

In Belgium briquetting is principally carried on in the Hennegau province, bordering on France, with the coal districts of Mons, Mittelland, and Charleroi, more particularly in the latter, and to a smaller extent, however, in the eastern districts of Namur and Liège

The material for the slowly but steadily developing industry is to be found mainly in the considerable quantities of small hard coal which have recently been produced in the Belgian pits The coking plants and briquette factories of the country worked up over 20 per cent. of the coal sold in the year 1906, and together employed about 4500 workers, of whom 1538 men were engaged in briquetting.

[1] According to "Bangaszati es Kohaszati lapok," from the *Osterreich Zeitschr für Berg- und Huttenwesen*

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BELGIAN COAL OUTPUT, COKE AND BRIQUETTE PRODUCTION IN THE YEARS 1900 TO 1906.[1]

Year.	Coal Output in 1000 Tons.	Coke produced in 1000 Tons	Briquettes produced in 1000 Tons				Average Value of one ton Briquettes Francs.
			Hennegau.	Namur	Liége	Total for the whole of Belgium.	
1900	23,463	2435	1091	108	197	1396	23·56
1901	22,213	1848	1236	106	246	1588	19·32
1902	22,877	2048	1282	99	236	1617	16·28
1903	23,797	2203	1366	81	236	1686	16·91
1904	22,761	2212	1401	105	229	1735	15·94
1905	22,775	2239	1332	122	258	1712	15·63
1906	23,570	2414	1457	151	279	1887	18·88

BELGIAN EXPORT AND IMPORT OF BRIQUETTES.

Year.	Exports.		Imports in 1000 Tons (Approximate.)	Excess of the Exports over the Imports 1000 Tons.
	In 1000 Tons.	Percentage of the Briquette Production in round numbers.		
1900	605	43·3	22	583
1901	714	45	17	697
1902	672	42	33	639
1903	624	37	14	580
1904	539	31	46	493
1905	480	28·6	73	407
1906	460	24·4	147	313
1907	426		151	275

The diminution of the exports on the one hand, and the increase of the imports on the other, in the last few years is to be traced to the fact that the use of briquettes in Belgium has grown at a greater pace than its own production.

D. FRANCE.[2]

In addition to the quantities of briquettes dealt with in the following tables, not inconsiderable, though unknown, quantities of briquettes are produced from sieved English and Belgian small coals

[1] *Statistique des industries extractives et métallurgiques*; further, *La Belgique*, 1830 to 1905. See also Baum, "Die Berg- und Huttenindustrie Belgiens," *Preuszische Zeitschrift*, 1907.

[2] The magnitude of the French coke and briquette production has not been given officially. The figures of the following table are taken from the paper *Comptes rendus mensuels, St Etienne*, and from the circulars issued in Paris by the "Comité central des houillères de France."

Year.	Coal Output, 1000 tons	Coke produced, 1000 tons.	Briquettes produced, 1000 tons				
			Pas-de-Calais	Nord.	Loire.	Gard and Herault	Total.
1900	32,722		326	253	198		...
1901	31,634		329	294	211		
1902	29,365	..	330	467	162	230[1]	
1903	34,906	1682	357	511	207	391	1466
1904	34,168	1674	380	533	213	351	1480
1905	35,347	1908	412	560	217	371	1560
1906	33,158	1818	379	580	216	418	1593
1907	36,168	2127	443	741	236	453	1873

The production of 9-kg. briquettes is very extensive. They are distinguished as:—

Torpedo type (for torpedo boats), containing about 3.5 per cent. ash
Cruiser type (for cruisers), containing about 4 to 5 ,, ,,
Ordinary type, containing about . . 5 to 9.5 ,, ,,

The latter are mainly used in the naval and commercial marine, on railways, steam trawlers, for driving locomobiles, thrashing machines, and so on.

Small briquettes of about 600 grm. find application in packet boats, etc., egg briquettes of 45 grm. made from anthracite coal are used as domestic fuels. The most important briquette-producing colliery company of France, the Compagnie d'Anzin (Nord), owns briquette factories at Saint-Vaast, Anzin, at the mines of Audiffret Pasquier and La Grange, which, equipped with Couffinhal, Biétrix, Middleton, and Robert presses, are able to produce about 1050 tons briquettes per day, or 315,000 tons in a year of 300 working days.

In the Pas-de-Calais district, the Ostricourt, Meurchin, Carvin, Lens, Vicoigne et Nœux companies own briquette factories with an aggregate of eighteen presses (1906). The quantities of coal worked up into briquettes amounted to, in 1904, 351,996 tons, 1905, 382,486 tons, while the production of briquettes (including egg briquettes) in 1905 ran to 410,256 tons.

The amount of coal used per ton of briquettes amounted to:—

1904	927 kg.
1905	932 ,,
1906	937 ,,

It has therefore steadily increased, corresponding to a diminution

[1] For the second half-year only.

in the use of pitch, which in 1905 amounted to 6·8 per cent. of the briquettes, but in 1906 to only 6·3 per cent of the briquettes.

The prices of briquettes are high; the best qualities range from 24 to 30 francs per ton, and generally correspond to the prices of cube coal and washed nuts, or are somewhat higher than these prices

The following table shows the exports and imports of briquettes for France

Export of Briquettes from France.[1]

Year	To Belgium.	To Switzerland	To other Countries	Coal Bunkers in Foreign Ships	Coal Bunkers in French Ships	Total
	tons	tons	tons	tons	tons	tons
1902	320	7099	16,177	1613	77,096	102,905
1903	700	1390	12,360	960	57,210	72,650
1904	656	1232	11,368	602	19,929	66,788
1905	1771	5042	16,731	307	32,380	89,231
1906	2355	2366	29,717	678	88,896	121,021
1907	1850	8800	33,980	200	68,520	113,410

Imports of Briquettes into France.[1]

Year	From England	From Belgium	From Germany	From other Countries	Total	Value
	tons	tons	tons	tons	tons	francs.
1903	75,950	150,737	31,737	53,317	611,771	11,930,000
1904	110,291	385,123	29,496	3,288	528,107	9,661,000
1905	92,472	278,811	26,100	1,915	398,399	7,309,000
1906	112,028	392,581	11,836	810	517,255	12,587,000
1907	133,790	516,370	13,340	1,430	691,930	15,983,000

Accordingly, the imports of briquettes into France were more than six times as great as the exports in the year 1907, and most of them were obtained from Belgium.

E. GREAT BRITAIN AND IRELAND.

Although exact statistics of the British exports of briquettes have been available for over forty years, the outputs of briquettes and coke in Britain were recorded for the first time in 1905.

Year.	Output of Coal	Coke Production	Briquette Production	
	gross tons = 1016 kg	gross tons.	gross tons.	ton = 1000 kg.
1905	236,128,936	18,037,985	1,219,586	1,239,099
1906	251,068,009	19,296,526	1,513,220	1,537,432

[1] According to the circulars issued in Paris by the "Comité central des houillères de France."

The following table gives a review of the distribution of the briquette production of the United Kingdom among the individual countries and counties

Country and County	Briquette Production		Value at Place of Production [1]	
	1905	1906	1905	1906
	gross tons	gross tons	£	£
England	109,702	158,217	68,273	100,277
Derby	27,490	13,398 [3]	18,886	8,292 [3]
Devon	1,600	1,150	1,650	1,192
Essex				
Gloucester				
Hampshire				
Lancashire	9,819	8,598	5,527	4,901
Monmouth	66,704	120,847 [5]	39,591	80,813 [6]
Nottingham				
Somerset	4,098	4,272	3,619	2,952
Stafford				
Sussex				
York		3,959		3,094
Wales	1,063,240	1,307,558	617,856	766,611
Glamorgan (Cardiff district)	1,063,240	1,307,588	617,856	766,611
Scotland	32,046	33,495	20,293	20,990
Ayr, Lanark	32,046	33,495	20,293	20,990
Ireland	11,591	13,950	11,249	11,168
Antrim, Cork, Down	11,591	13,950	11,249	11,168
Whole kingdom	1,219,586	1,512,220	717,671	899,046

From the foregoing table it follows that the centre of the British briquette industry lies in the county of Glamorgan Wales, in the celebrated Cardiff district, which in the years 1905 and 1906 was responsible for 88 to 89 per cent of the total briquette output of the whole kingdom The whole of the remaining districts are of quite secondary importance Because of the peculiar position of the district close to one of the most important ports (Cardiff) it is not surprising that it supplies almost the whole of the oversea export For this purpose, large and very large briquettes are mostly prepared, the individual weights being up to 28 lb (= 12 7 kg), which just corresponds to the burden of a man for overland transport on foot These very large blocks are principally sent to the West and East Indies

[1] From the *General Report and Statistics relating to the Output and Value of the Minerals raised in the United Kingdom*, part iii, issued by the Home Office

[2] Including Essex, Gloucester, Hampshire, Nottingham, Stafford, Sussex and York

[3] Together with Derby

[4] Including Essex, Hampshire, Nottingham, Stafford, and Sussex

[5] Together with Monmouth.

[6] Including Gloucester

As will be seen from the following summary of the briquette exports of Great Britain, a total of 1,108,455 and 1,377,209 tons were exported in the years 1905 and 1906 respectively. This corresponds to about 91 per cent. of the total briquette production, leaving only 9 per cent. for home consumption.

The export of British briquettes extends to almost all countries in the world. Of late years they have been sent mostly to Italy, France, Algeria, Spain, with the Canary Islands and Mexico.

EXPORT OF BRIQUETTES FROM GREAT BRITAIN.

To	1904.	1905.	1906.
	tons.	tons.	tons
Russia —			
Northern ports	42,654	23,907	18,421
Southern ports	10,410		
Sweden	330	1,049	
Norway	1,326	1,013	1,899
Denmark (including Faroe Isles)	.		
Germany	75	20	
Holland	10	50	243
Belgium	.	10	.
Channel Islands	230	134	156
France	156,480	124,240	158,255
Portugal, Azores and Madeira	26,746	22,025	4,113
Spain and Canary Isles	155,875	157,475	124,167
Gibraltar	2,510	...	.
Italy	176,520	161,925	275,384
Austria-Hungary	29,432	58,618	74,172
Malta and Gozzo	20,009	22,131	12,821
Greece	40,274	25,591	35,325
Roumania	.	1,110	600
Turkey	32,552	12,114	37,151
Egypt	25,692	12,368	17,248
Tripoli and Tunis	13,932	20,830	25,399
Algeria	120,637	121,958	155,858
Morocco	400	413	1
West Coast of Africa	18,270	32,315	50,796
Ascension Island			1,912
St Helena			1,117
British South Africa	5,750	2,985	2,542
East Coast of Africa	3,721	6,855	1,700
Abyssinia	700	1,362	1,800
Madagascar	...		
Réunion	..	.	...
Mauritius	9,787	2,010	1,517
Seychelles	...	..	3,010
Aden	4,940	.	
Portuguese Indies	...		2,500
British East Indies territory	8,565	4,013	1,024
Straits Settlements	15,068	...	5,000
Ceylon	..	.	.
French Indo China	4,686		...
China and Hong-Kong	27,088	10,086	10,663
Japan and Formosa	10	...	.
New Zealand	.	453	.
British North America	...	.	300
United States on Atlantic Coast	...	.	1,810

EXPORT OF BRIQUETTES FROM GREAT BRITAIN—*continued.*

To	1904	1905	1906
	tons.	tons	tons
Bermuda	2,033	2,390	1,849
British West Indies	18,038	16,185	18,553
Remainder of West Indies	4,387	7,395	13,170
Mexico	122,554	116,801	123,945
Central America	8,152	5,978	26,103
Columbia	1,046	1,154	2,960
Venezuela	20,355	14,384	9,015
Peru	41	8	80
Chili	17,934	24,594	45,342
Brazil	17,499	56,168	96,376
Uruguay	635	1,185	.
Argentine	10,096	4,163	9,122
Falkland	30		
Total	1,237,784	1,108,455	1,377,209

F. UNITED STATES OF AMERICA.[1]

Coal briquetting is only in its infancy, and is limited to a few, mostly new, installations in the States of Pennsylvania (2), Michigan (1), and New York. There are no figures relating to the magnitude of the yearly outputs.[2]

Year	Output of Coal (Soft and Hard Coals)	Coke Production	Briquette Production
	metric tons	metric tons	
1903	324 173,000	29,929,000	?
1904	319,168,000	21,465,000	?
1905	356,456 000	29,240,000	?
1906	375,617,000	29,657,000	?

Various causes are responsible for this extraordinary deficiency of the United States, whose output of coal is by far the greatest in the world:

(1) The excess of cheap rough materials for use as fuels;

(2) The anthracite merchants are not inclined to instal briquetting plants. In the anthracitic regions of Pennsylvania there is no keen competition from cheaper soft and bituminous coals. Nevertheless, the existing material is quite suitable for briquetting; and

[1] *Bi-monthly Bulletin of the American Institute of Mining Engineers*, 1907, No 17 pp 789 828

[2] *Ibid*

(3) The difficulty of regularly obtaining cheap coal-tar pitch in sufficient quantities (Experiments made at the Experimental Station of the U S Geological Survey at St Louis, carried out on all possible kinds of bonds, had shown that this was the most suitable binding material, in the same way as it had been given exclusive consideration in Europe for a long time.)

However, of late years two briquette factories (one each in the States of Pennsylvania and Michigan) have been established, in which, so to speak, the interests of the coal-tar pitch and the briquetting industries go hand in hand. These are the installations of the United Gas Improvement Co. at Point Breeze, Philadelphia, and of the Semet-Solvay Co. at Del Ray, Michigan. Both are manufacturers of coal tar, and the plants are constructed for the briquetting of waste anthracite and quenched coke. The first-named company uses the briquettes so prepared for the manufacture of water gas in its own works. The briquetting plant is illustrated and described above (p. 213 *et seq*)

In addition to these works there is a second works in Pennsylvania, that of the Scranton Anthracite Briquette Co., but worked by the Delaware, Lackawanna and Western Railroad for the production of briquettes for the locomotives

In New York State the following companies have laid down briquetting plants:

1. New Jersey Briquetting Co in New York had a factory built in 1904 to 1905 to operate the system of the Zwoger Fuel Co., whose experimental plant is discontinued

2 The Briquette Coal Co of New York, with one press from each of the companies Schuchtermann & Kremer of Dortmund and H Steven of Charleroi, Belgium.

3 National Fuel Briquette Machinery Co., New York, with presses by Hubert J. Debauche of Gilly, Belgium

4. North American Coal Briquette Co, New York, working to the Forst briquetting process, the secret binding material of which consists for the most part of coal-tar pitch.

5. Traylor Engineering Co., New York, working according to the Mashek system.

The briquettes obtained by this method, with presses similar to egg roll presses, take the shape of eggs or small spheres which are most adapted to American commercial conditions and use (mostly in slow-combustion stoves in place of anthracite nuts).

G. SUMMARY AND ESTIMATE OF THE COAL-BRIQUETTE PRODUCTION OF THE WORLD.

According to the foregoing statistics, the coal briquette outputs of the most important countries (with the exception of the U.S.A.) reached the following figures in recent years :—

Year	German Empire	Belgium	France	Great Britain and Ireland	Austria Hungary.
	1000 tons	1000 tons	1000 tons	1000 tons	1000 tons
1905	3078	1712	1560	1239	281
1906	3555	1887	1593	1537	about 300
1907	4003	?	1873	?	?

Consequently, the combined production of these countries amounted to :—

In 1905 about 7,877,000 tons

It became in 1906 8,875,000 „

and reached in 1907 9,700,000 „

To this should be added the coal briquette production of the U.S.A., which, though unknown, is no inconsiderable quantity, as well as the output of other countries in the world (Russia, Roumania, Turkey, English and Dutch Colonies in Eastern Asia, China, Japan, and so on). In these countries, so far as is known, there are only few and isolated and mostly small briquetting plants whose total output is very difficult to estimate. Probably an approximation of 1,300,000 tons, including the production of North America, is not very far removed from the truth.

In this case a total sum of about 11,000,000 tons is obtained for the present coal-briquette production of the world.

PART II.

PREPARATION OF BROWN-COAL BRIQUETS AND WET COMPRESSED BLOCKS.

SECTION I

NATURE, COMPOSITION, AND ADAPTABILITY TO BRIQUETTING OF BROWN COALS. USUAL METHOD OF BROWN-COAL BRIQUETTING.

COMPARED with coals, brown coals are of much more frequent occurrence in Germany, and permit of briquetting without a special binding material. It is especially necessary therefore to become acquainted with the nature of this species of coal, its properties and its adaptability to briquetting.

A. PROPERTIES AND COMPOSITION OF BROWN COALS.

I. GENERAL.

Generally speaking brown coal includes the whole of the solid fuels (usually brown in colour) of the tertiary formation. Coals of brown colour having the chemical composition of tertiary coals occur outside the tertiary formation, but the latter is always the main source of such coals. The following short table[1] shows at a glance the deficiency of oxygen in brown coal and coals as compared with peat and uncharred wood and simultaneously the enrichment in carbon, calculated on the dry material free of ash.

		C	H.	O(+N)
Wood	about	50 per cent	6 per cent	44 per cent
Peat	,,	57 ,,	6 ,,	37 ,,
Brown coals of the tertiary formation	,,	70 ,,	5 ,,	25 ,,
Coals	,,	82 ,,	5 ,,	13 ,,

The brown coals of the tertiary formation vary greatly among themselves.

With regard to their physical properties, they form, according to their origin and degree of decomposition, a fibrous bast-like woody,

[1] According to H. Potonié, 'Entstehung und Klassifikation der Tertiärkohlen,' *Die Deutsche Braunkohlenindustrie*, Halle, 1907.

dense, earthy, or resinous waxy mass. The fracture is fibrous or conchoidal, matt or bright, smooth or rough, earthy or slaty, the colour usually light to dark brown, but occasionally pitch-black, seldom yellowish-grey, and sometimes almost white even (Pyropissit). The streak of lignite, like the finest powder of the material, is brown, the hardness varies between 1·0 and 3·0, and the specific gravity (weight of 1 c.c.) between 0·8 and 1·5 (grm.), but the ordinary burning fuel varies only between 1·2 and 1·5.

From the point of view of their origin and chemical composition, the brown coals, in the widest sense, belong, according to H. Potonié,—

(1) To the Sapropelithenes derived from decaying slime (Sapropel);

(2) To the humus minerals like most of our fuels, or

(3) They are strongly resinous, waxy resinous, or products containing wax, or even fossil resins (Liptobiolithe).

The briquetting and wet compression deals exclusively with the humus minerals belonging to the second group, which are the true brown coals. This species of coal consists, like peat, coal, and even anthracite, on the one hand, of plant tissue which has not proceeded to complete decomposition but has more or less maintained its structure, and, on the other hand, of a dark amorphous, humus substance which penetrates and fills the whole of the cavities in the tissue.

II. Content of Water

Most of the crude, wet brown coals contain a high content of water, ranging from 40 to 60 per cent. In the principal districts of Central and West Germany the water content amounts on an average as follows:—

In the	Magdeburg-Helmstedt district	48	per cent.
,,	Halle and Leipsic ,,	52	,,
,,	Meuselwitzer ,,	55	,,
,,	Cologne ,,	55	,,
,,	Senftenberg ,,	58	,,

(compare also the collection of chemical analyses given on p. 277 of German brown coals as obtained from the pit).

In Bohemia, only the brown coals from the north-west basin (Eger-Falkenau) show a high content of water, on an average about 43 per cent.; while the brown coals of the main basin (between Brux and Aussig) only contain from 18 to 37 per cent., with an average of about 26 per cent. Glance and pitch coals are uncommonly dry, under certain circumstances containing as little as 2 per cent. moisture. In any case,

they result from powerful geological phenomena (breaking through of basalt and similar upheavals, mighty overlapping and folding). When allowed to dry in the atmosphere pulverised brown coal loses a large proportion of its moisture. Air-dried coal when heated to 105° C. gives off further quantities (12 to 22 per cent.), and, conversely, the completely dried coal absorbs 10 to 15 per cent. moisture from the atmosphere.

An accurate determination of the water contained in wet brown coal from the pit requires special measures of precaution.[1] The samples taken from the various parts of the storage-places must be placed immediately, at the place of sampling, in glass bottles fitted with ground-glass stoppers. In the laboratory the whole sample is emptied into dishes, weighed, and allowed to stand exposed to air in a warm place, when the greatest part of the water evaporates. The air-dried sample is weighed again and the loss of water determined. Then and only then is the sample pulverised and prepared for further testing. The second determination of water is then carried out by the method used for coals and other materials. The sample is heated for two hours in a drying oven at a temperature of 105° to 110° C. For greater accuracy this determination is made at 100° to 105° C. in a current of carbon dioxide in order to prevent chemical changes occurring in the coal. The first and second drying experiments then give the approximate amount of water originally present.

The total content of water is always somewhat higher, since a portion is always retained at any temperature. This can easily be proved by complete drying or by a combustion analysis of the same coal.[2] In this case 3 to 6 per cent. more water is found, of which a portion is due to the water resulting from decomposition of bitumen and other carbonaceous materials.

Brown coals undergo a chemical change even at 100° C. This depends on the one hand on the loss of carbon dioxide and combustible gases in addition to water, and on the other hand to the absorption of oxygen.

The water content of brown coal is not only of a hygroscopic, mechanically held nature; it appears more probable, according to B. Kosmann,[3] that a certain part of it belongs to the chemical constitu-

[1] Junemann, p. 184.

[2] W. Scheithauer, "Der chemische Vorgang bei der Brikettierung der Braunkohle," *Z. Braunkohle*, 1902, No. 13, p. 159.

[3] *Verhandlungen des vierten allgemeinen deutschen Bergmannstages zu Halle a. S.*, 1889, p. 103.

tion of the brown coal itself as "chemically combined water" or "water of hydration" Kosmann attributes 25 per cent. of the water in the coal to "water of hydration," while W Scheithauer[1] found in his experiments that it is very difficult to fix a definite limit for the content of water of hydration in the individual kinds of coal, and that in this connection, in addition to other properties, the density of the coal is of considerable importance. According to him, the average content of water of hydration can be taken as 20 per cent. As a general rule, therefore, it may be taken in a mine moist brown coal with a total water content of 40 to 60 per cent, 20 per cent. may be regarded as water of hydration and 20 to 40 per cent. as hygroscopic moisture

For the production of good briquettes the complete removal of the hygroscopic water from the brown coal is an essential condition; in many cases it is even necessary to carry the drying still further. In the preparation of the lesser valued wet compressed briquettes, however, still more water is added, and a subsequent drying only is necessary

III Elementary Composition

Brown coals are composed of carbon, hydrogen, oxygen, nitrogen, sulphur, and the constituents of the ash The data given above in the comparison of wood, peat, brown coal, and coal, that the older formations are poorer in oxygen but richer in carbon, applies also to the various brown coals, since the oldest (eocenic and oligocenic) brown coals, such as, for example, those of the western portions of the Merseburg district, the state of Thuringia, the Leipsic area, and so on, tend to show relatively more carbon and less oxygen than those of the newer tertiary (miocenic and pliocenic) brown coals for example, those of Niederlausitz, the Lower Rhine, the Wetterau, and so on

The brown coal standing closest to wood is most rich in oxygen even if in very wide limits (17 to 36 per cent). The nitrogen content of brown coal is very low, 0 to 2 per cent.

From the following table of nine analyses[2] of various kinds of brown coal (dried as previously described), it is easy to see the limits between which the elementary compositions vary. Still better comparisons are obtained if the analyses are calculated on the pure coal, *i e* the combustible matter free of ash (columns 8 to 10).

[1] "Der chemische Vorgang bei der Brikettierung von Braunkohle," *Z Braunkohle*, 1902, No 13, p 159

[2] According to E Erdmann, "Eigenschaften der tertiaren Braunkohlen," *Die Deutsche Braunkohlenindustrie*, Halle, 1907, p 21

COMPOSITION OF VARIOUS LIGNITES. Dried at 105° C.

No.	Kind of Coal.	Origin.	C.	H.	O. (incl. N. and S.)	Ash.	Calculated on the Pure Coal: C.	H.	O. (incl. N. and S.)	Analysis by
			per cent	per cent	per cent	per cent	per cent	per cent	per cent	
1	Brown coal	Laubach Hesse	57·28	6·03	36·1	0·59	57·62	6·07	36·31	Liebig
2	Earthy coal (fuel coal)	Heydt pit at Halle Amendorf	57·43	5·88	24·83	11·86	65·16	6·67	28·17	Erdmann
3	Rough coal	Costebrau (West Hotlbus mining district)	62·11	4·75	26·23	6·91	66·72	5·10	28·18	Langbein
4	Rough coal	Leonhard, near Meuselwitz Zeitz mining district	61·49	4·95	23·26	10·29	68·47	5·51	26·02	Langbein
5	Common lignite	Schönfeld, Bohemia	61·2	5·17	21·28	12·35	69·82	5·90	24·28	Heintz
6	Splint coal	Wilhelmstund pit (Westerwald)	62·86	6·76	19·43	11·01	70·57	7·60	21·83	Casselmann
7	Pitch coal	Penzberg, Upper Bavaria	69·50	4·63	20·47	5·4	73·47	4·89	21·64	Till
8	Gas coal	Falkenau, Bohemia	70·54	6·67	13·81	8·98	77·50	7·33	15·17	Langbein
9	Glance coal[1]	Meisner Hesse	82·0	4·2	5·9	7·9	89·03	4·56	6·41	Gräger

From numerous analyses by Langbein[2] it follows that the German brown coals of the kingdoms of Saxony and Prussia contain when calculated to pure coal

Carbon	64·01 to 72·88 per cent
Oxygen	14·45 „ 30·27 „

IV. CONTENT OF HYDROGEN AND BITUMEN

The content of hydrogen depends to a very large extent on the content of bitumen, since bituminous coals are very rich in hydrogen. There are various views, varying partly from each other, as to the meaning of the word "bitumen." By the bitumen of brown coals is understood a mixture of wax or resin-like substances, principally hydrocarbons, which yield tar on dry distillation, on the one hand,[3] and on the other the solubility in benzol, benzene, or similar solvents is regarded as the principal property of the bitumens of the humus coals[4] (and therefore of the brown coals in the strict sense).

The whole of the brown coals contain tar-producing bitumen; the

[1] Brown coal largely coked by molten red-hot basalt.

[2] *Die Auswahl der Kohlen*, Leipsic, 1905.

[3] W. Scheithauer, "Der chemische Vorgang bei der Brikettierung der Braunkohle," *Zeitschr. Braunkohle*, 1902, p. 159.

[4] E. Erdmann, *a.a.O.S.*, pp. 27-28.

ordinary earthy burning coal serving as fuel which contains in the natural moist state about 50 per cent moisture, contains 2 to 3 per cent., the distilling coals, however, which have been worked up of late, contain 5 to 10 per cent.[1] Distilling coals with more bitumen, 20 to 30 per cent and over, have become very scarce compared with the time of the beginning of the distillation industry (fifties and 'sixties of the last century). The richest distilling coal Pyropissit, containing bitumen to the extent of 40 per cent and over, has had only a limited application, and during the last ten years has diminished to inconsiderable quantities from the distillation coal strata.

Distillation coal is mainly obtained and put to use in the brown-coal district of Saxon Thuringia. By a dry distillation in a closed vessel at a temperature of 150° to 200° C. the brown coal is converted into volatile compounds, which are given off, and a residual coke (quarry coke). The first are obtained partly in the form of permanent gases, the main portion condenses as tar, but at the same time certain constituents of the bitumen pass over as solid paraffin hydrocarbons, a change which takes place to a greater extent in the subsequent distillation of the tar. Consequently, the bitumen is decomposed by these operations, resulting chiefly in the production of saturated and unsaturated hydrocarbons of the fatty series, together with acid and basic substances with the separation of water and carbonic acid. The distillation therefore forms the groundwork of the paraffin and mineral oil industries.

Analyses of burning coals, distillation coals and Pyropissit dried at 105° to 110° C. in a stream of carbon dioxide recently carried out in the University Laboratory for Applied Chemistry at Halle gave the figures shown in the following table for the content of hydrogen.[2]

No.	Kind of Coal	Origin	H		Coals 2 to 4 gave the following Results on Distillation Analysis			
			In the Coal containing Ash	Calculated on the Pure Coal	Tar	Water	Gas	Coke
			per cent	per cent.	per cent	per cent.	per cent	per cent
1	Earthy burning	Greppin	4·88	5·51	..		.	
2	,, ,,	Waldau, Osterfeld	6·42	7·04	18·13	1·61	26·66	50·30
3	Distillation	,, ,	7·62	8·27	38·86	3·80	22·69	34·64
4	Pyropissit	. Kopen, Weissenfels	11·63	12·60	68·27	3·79	14·74	13·20

[1] Scheithauer, "Das Bitumen der Braunkohle," *Zeitschr. Braunkohle*, 1904, p. 97.
[2] E. Erdmann, *ibid.*, pp. 22–23.

Properties of Bitumen. Bitumen can be partially extracted from distillation coal and from nearly every brown coal by treatment with a solvent; the remainder stays in the coal, and can only be recognised by the formation of tar on dry distillation. The ratio of these two portions varies considerably. On an average, 40 to 50 per cent. of the total bitumen (occasionally as much as 70 per cent. and above) remains insoluble in the coal after the extraction. Both bitumens possess the same properties; they give tars of quite similar properties when separated from the products of dry distillation.

Petroleum benzin, light lignite tar oils and benzene especially are used as solvents for bitumen. There is no method other than that of dry distillation which will free the coal of bitumen. In appearance bitumen is a yellowish to dark brown, occasionally reddish, fairly brittle mass similar to ozokerite (earth wax) or carnauba wax. Its shade of colour is determined by the purity of the parent material. The specific gravity = 1. As a rule the melting point of bitumen lies between 70° and 80° C., sometimes it is as high as 90° C. On heating, bitumen decomposes with the formation of oil, paraffin and gases.

It is very difficult to fix the exact chemical composition of bitumen, since it consists of a mixture of numerous substances which can be characterised and separated from each other only with great difficulty in certain cases, or cannot be separated at all.

C. Hubner[1] has recently isolated from the portion of the bitumen extracted with benzol, and which is soluble in ether, a ketone of the composition $C_{16}H_{32}O$, and the ketone $C_{1[illegible]}H_{[illegible]}O$ from the portion insoluble in ether. Still more recently Graefe[2] has obtained accurate values of the properties, behaviour, and determination of the value of the lignite bitumens prepared technically. Experiments carried out by Ramdohr and v. Boyen to extract the soluble bitumen from distillation coal on the large scale with as little decomposition as possible, have led to the preparation of Montana wax. This is obtained by several distillations of the bitumen with steam superheated to 250° C., or by a single distillation carried out under diminished pressure. It is a yellow, wax-like body of high melting-point, which consists, according to Hell,[2] of an acid having the formula $C_{29}H_{58}O_2$ (geoceric acid (Montana acid)) and an unsaturated hydrocarbon.

[1] *Beiträge zur Kenntniss der Schwelkohle*, Halle, 1903.
[2] *Zeitschr. Braunkohle*, vol. iii. p. 242; vol. iv. p. 217.

V. Sulphur and Ash Content.

Sulphur, which is never absent from brown coal, exists partly in organic combination, partly in the form of inorganic admixtures, principally as iron pyrites (marcasite spear pyrites), and also as sulphates when it exists in very varying proportions. E. Erdmann found from his own analyses that the sulphur content of German brown coals lies between 0·62 and 1·87 per cent., which corresponds to 1·16 to 4·56 per cent. when calculated on the pure coal. As an average sulphur content of German brown coal containing its natural moisture the figure 1 to 1·5 per cent. can be taken. This corresponds to 2 to 3 per cent. for the dry coal. Occasionally, however, the content is very much higher—up to 10 per cent., and even more. During the combustion of the coal on the fire-grate only a portion of the total sulphur is evolved as sulphur dioxide or sulphur trioxide, while the residue remains in the ash.

The content of ash of brown coals used for firing amounts to between 2 and 10 per cent., and seldom exceeds 6 per cent. of the dry coal in the province of Saxony. Qualitative chemical analysis of the ash of brown coals shows that the oxides of iron, aluminium, calcium, smaller quantities of magnesium, potassium, sodium, and occasionally other metals occur as the bases; while silica, sulphuric acid, sulphurous acid, sulphuretted hydrogen, carbonic acid, traces of hydrochloric acid, and occasionally phosphoric acids occur as the acids.

In addition the ash contains varying quantities of unburned carbon (soot).

Generally speaking, the flue ash possesses the same composition as the ash remaining on the grate.

VI. Analysis of Mine-Moist Brown Coals.

The following summary gives the results of a number of old and new analyses of pit-moist German brown coals arranged according to the district of origin:—

No	Origin	Carbon	Hydrogen	Oxygen, including Nitrogen and Volatile Sulphur	Total Combustible Substances	Ash	Water
	MARK AND NIEDER[illegible]						
		per cent	per cent	per cent	per cent	per cent.	per cent
1	Reichenwalde .	33·07	2·52	15·14	50·73	4·27	45·00
2	Furstenwalde .	35·84	3·32	14·61	53·77	5·02	42·21
3	Mark Braunkohlenwerk	30·80	2·34	12·16	45·30	10·05	44·65
4	Groszraschen .	28·15	2·28	12·95	43·38	2·27	54·35
5	Buckgen .	26·01	1·87	10·94	38·81	2·98	58·00
	KINGDOM OF SAXONY AND A[illegible]						
6	Markranstadt .		.		39·43	7·16	53·41
7	,, .	.	.	.	40·75	7·50	51·75
8	,,	..	..	..	34·92	8·08	56·00
9	Borna				40·96	4·24	55·30
10	Brandis	..			35·88	12·77	51·35
11	Meuselwitz .				43·06	4·59	52·35
12	,,	30·63	2·68	12·15	45·46	5·15	49·24
13	,,	27·00	2·14	14·36	43·50	3·60	52·10
14	Rositz .	27·29	2·51	11·76	41·56	10·30	48·14
15	,,	.			44·09	1·84	54·17
	PROVINCE OF SAXONY, ANHALT, AND BRUNSWICK						
16	Naumburg	29·61	2·77	11·27	43·65	4·63	51·72
17	Halle a. S. .	31·80	2·70	12·90	47·40	6·40	46·20
18	Zscherben .	35·12	3·12	9·52	47·76	6·84	45·40
19	Bitterfeld .				42·13	9·21	48·63
20	Gnadau .	31·43	2·76	11·23	45·42	7·07	47·03
21	Muhlingen	31·26	2·71	13·94	47·91	6·97	45·12
22	Atzendorf	35·61	3·12	13·67	47·40	6·65	40·95
23	Forderstedt	28·64	1·84	13·55	44·03	6·37	49·60
24	,, . .	30·72	2·68	14·56	47·96	5·57	46·46
25	Unseburg .	33·71	2·78	13·55	50·04	6·13	43·84
26	Neindorf	32·69	2·56	14·29	49·54	8·09	42·37
27	,, . .	36·12	2·98	11·40	50·50	5·05	44·23
28	Wolmirsleben	34·66	2·61	12·13	48·90	6·90	43·70
29	Schneidlingen	31·50	2·40	12·23	46·14	8·93	44·93
30	Thale.	30·17	2·16	12·87	45·20	4·80	50·00
31	Nachterstedt	31·85	3·04	13·79	51·68	6·07	42·95
32	Uellnitz . .	29·66	2·98	14·70	47·34	6·20	46·55
33	Ascherslebem	32·49	2·75	13·21	48·45	6·55	45·00
34	,, .	26·65	2·40	12·52	41·57	6·93	48·50
35	Frose i. A. . .	31·94	2·67	13·31	47·92	6·32	45·80
36	Weiszsandt . .	31·26	2·61	11·91	44·78	6·42	47·80
37	Hammersleben . .	31·84	3·21	11·00	46·05	6·93	47·01
38	Saxon Province (average of 14 different mines)	29·34	2·70	13·36	45·40	7·10	47·00
39	Hotensleben	34·42	2·62	13·09	50·13	5·57	44·30
40	Offleben .	34·12	2·61	14·30	51·03	6·29	43·00
41	,, . . .	32·55	2·65	12·58	47·78	5·98	46·03
42	,, . . .	34·55	3·06	11·44	49·05	5·00	45·95
43	Volpke . .	29·64	2·46	10·68	42·78	9·22	48·00
44	Harbke . .	30·16	2·47	12·56	45·19	6·34	48·44
45	,, . . .	34·76	2·51	13·00	50·27	5·93	43·80
46	Trendlebusch . .	33·72	2·65	12·85	49·22	5·78	45·00
47	Frellstedt . . .	32·63	2·65	13·12	48·40	5·70	45·93
48	Duderode . .	27·09	2·49	12·93	42·51	8·62	48·60
	HANNOVER AND HESSE.						
49	Volpriehausen . .	30·99	2·39	14·23	47·61	3·89	48·50
50	Meiszner . . .	36·44	2·62	12·06	51·12	7·98	40·90
	LOWER RHINELAND (HILLS).						
51	Bruhl. . . .	23·86	1·82	9·50	35·18	4·64	60·18
52	Horrem . . .	29·78	2·03	12·06	43·87	2·18	53·95
53	Quadrath . . .	28·75	2·17	11·91	42·83	1·86	55·31

VII. Laboratories for Coal-Testing

At many brown-coal mines and briquette factories small laboratories are installed so that raw coal, during the various stages of the wet and dry operations, and finished briquettes can be tested for their content of water, ash, bitumen or tar, yield of coke, and, under certain circumstances, for the sulphur content, according to requirements. The establishment and maintenance of such laboratories require only a very moderate outlay. As an example, the arrangement of the coal-testing laboratory at the Treue pit at Offleben (Brunswick colliery) will be dealt with here in detail. The laboratory is situated in the offices near the briquette factory of the works in a small room near the working room of the inspector of mines, and contains :-

1 balance with weights of 0.002 to 200 grm.
1 mortar of 200 mm. outside diameter.
1 sieve of 200 mm. outside diameter.
3 large model Bartell burners.
3 glass funnels, 10 cm. diameter at the top.
10 retorts, each of ½ litre capacity.
6 receivers, 6 cm. diameter, 30 cm. long.
1 drying oven, 15 × 15 × 30 cm.
2 pairs crucible tongs.
6 drying dishes (porcelain evaporating dishes), 8 cm. diameter.
6 iron combustion dishes, 6 cm. diameter.
1 pair tongs, 25 cm. long.
Various small glass tubes of 5 to 8 mm. bore.
1 thermometer from −36° to 360° C.
1 tripod, 20 cm. high.
Various retort brushes and pencil brushes.

The whole of the materials were obtained from the well-known firm Warmbrunn, Quilitz & Co. of Berlin,[1] and cost altogether about 190 marks.

For accurate drying tests at 105° C. in a stream of carbon dioxide, a cylinder of compressed carbon dioxide and a few accessories are necessary.

A trained individual is hardly necessary to carry out the tests, which are not made continually day after day, but are only taken occasionally when necessities arise. Usually one of the works attendants can be released and taught to do this in addition to his ordinary

[1] Berlin, N.W., Heiderstrasze 55–57.

duties At the Treue mine the mine inspector, who also controls the briquette factory carries out the tests himself

The equipment and use of such small laboratories is very much to be recommended Their utility is quite obvious, considering that the raw coal supplied to the briquette factory changes its properties considerably according to the parts of the seam or stock being worked up, according to the special storage conditions to the season and state of the weather (in open workings) and that the working of the briquette factory, more especially the drying operations, must be adapted to these varying properties of the coal

B THE ADAPTABILITY OF BROWN COALS TO BRIQUETTING.

The capability of the earthy brown coals to form solid and tenacious briquettes which can be transported long distances, without the addition of binding materials but simply by the application of high pressures, amounting to 1200 to 1500 atmospheres in the Exter coal press is caused by the content of water and bitumen, as well as by the degree of granulation hardness and strength of the coals

With regard to the content of water, it has already been pointed out above that the considerable quantities of hygroscopic mechanically held water must be removed by corresponding drying, and that only the apparently chemically combined water called "hydrate" or "constitution water, which amounts to 20 per cent at the outside, should be allowed to remain in the coal But in many cases it is necessary to carry the drying further, even down to 15 or 12 per cent, or, under certain circumstances, to 10 or 8 per cent, in order to obtain briquettes of the best properties This applies principally to coals with a high content of bitumen and for the production of the domestic brands of briquettes, whereas for the preparation of industrial briquettes, in which such rigid requirements are not demanded the coals are not usually so thoroughly dried As will be seen from the analyses of lignites given below, the water content amounts to --

12 to 17 per cent in most cases,
14 „ 15 „ „ on the average

From the chemical point of view, the residual water prevents the decomposition of the dry brown coal on heating, which otherwise easily takes place with the evolution of gases It also exerts a mechanical action in promoting or partially helping the cohesion of the coal particles during compression

The rôle of the bitumen content has already been dealt with in a general way, to the effect that it principally plays the part of a binding material. This has of late ceased to be recognised in various sources. According to Scheele[1] and Kegl,[2] the formation of briquettes more probably depends on a surface tension of the particles of dust, the principal cause is that under pressure the particles are brought into intimate contact with each other and the air forced from between them, while the large internal spaces are filled with coal dust and the small spaces filled with moisture.

This explanation certainly has a certain amount of justification, and there is much to be said in its favour, but at all events the contradiction of the fact that bitumen exerts considerable influence goes too far.

Convinced that this question could not be solved by theoretical considerations and laboratory experiments alone, W. Scheithauer[3] has for some years carried out a systematic series of practical experiments which, so far as they concern the capability of briquetting, have been made in the research laboratory of the Zeitzer Eisengieszerei und Maschinenfabrik Akt.-Ges. The briquetting experiments dealt with —

(*a*) Distillation coals which, on extraction with benzol, showed that 18 per cent. of bitumen dissolved, and in the distillation test produced 31 per cent. tar (in the natural moist condition and working on a manufacturing scale a yield of about 10 per cent. of tar was obtained).

(*b*) The same coal, after it had been treated for the production of Montana wax on a manufacturing scale, still showed 1·9 per cent. soluble bitumen on extraction with benzol, and gave 14 per cent. tar on the distillation analysis.

(*c*) Another distillation coal which was completely extracted with benzol, but still showed 14 per cent. tar by the distillation analysis, and, finally,

(*d*) Porous quarry coke, which is distillation coal from which the bitumen has been completely removed, containing the pure carbon itself along with the ash constituents.

These experiments gave the following results:—

(*a*) Distillation coal, as known for a long time, is very difficult to briquette, and in fact the better and richer in bitumen the less adaptable is the coal to briquetting.

[1] *Zeitschr. Braunkohle*, vol. i., 1902-03, p. 31.
[2] *Ibid.*, vol. ii., 1903-4, p. 105.
[3] *Ibid.*, vol. iii., 1904, p. 97.

(*b*) Under normal pressures, however, distillation coal from which the bitumen has been partially removed (as under *b* and *c* above) gives faultless briquettes.

(*c*) Quarry coke can, under no circumstances be briquetted without the addition of a tarry, binding material even when water is added in suitable quantity and the pressure increased to 2000 atmospheres.

(*d*) By the addition of hard pitch or bituminous brown coal or bitumen extracted from brown coal by extraction, good, strong briquettes can be obtained from quarry coke when the additions have reached the correct degree. Accordingly, it can be taken that lignite bitumen is a sort of binding material, and determines the briquetting properties to a large extent if it is not allowed to exceed a certain amount. According to Vollert,[1] this upper limit should not be above 13 to 14 per cent. On the other hand, the bitumen content should be very much less especially with many kinds of soft coals. The Rhenish brown coals for example, which do not contain quite 1 per cent bitumen soluble in benzol, can be briquetted very well.

A possible fusion of the bitumen during compression can hardly be taken into account since it is possible to prepare good briquettes by means of a slowly increasing pressure in a screw press without even approximately reaching the melting-point of the bitumen (70° to 90° C., see p. 275).

Further, the degree of granulation, hardness, and strength of the coal are of importance in determining the capability of briquetting. With regard to the degree of granulation, it is necessary that the coal should be well pulverised, and that in addition to pieces of different sizes a certain quantity of powder and coal dust must be present to fill up the small spaces between the larger grains and increase the surface tension of the particles. The proportion of briquetting coal to dust must not exceed a certain amount, otherwise strong briquettes are not obtained, since coal dust can scarcely ever be briquetted alone.

Hardness, which along with the strength of the coal is largely determined by the special nature of its formation (p. 270), is of influence inasmuch as hard and strong coals must be more finely pulverised, require a higher pressure, and cause a greater wear of the parts with which they come into contact, especially the press moulds and stamps, than soft coals, which of course give more dust, allow the pieces to be squashed by the press stamps more easily, and are consequently more adapted to briquetting.

[1] *Der Braunkohlenbergbau*, 1889, p. 242.

Particles of *lignite* only require finely pulverising and compressing with definite quantities of soft coal which surround the lignite pieces. They are, however, for the most part previously sorted by sieving and burnt in the boiler-house.

The non-aqueous brown coals of the principal coal district of North-west Bohemia, which have apparently been considerably changed by the heat of liquid lava and are distinguished by a conchoidal fracture, great hardness, strength, and calorific value, cannot as a rule be briquetted without the addition of binding material. They behave very much like the still harder pit coals, but they are much more porous, and consequently require a much greater addition of binding material. The result is that the briquetting of the Bohemian coal is too costly, and is only carried out in exceptional circumstances.

In addition to certain properties of the brown coals themselves, the accessory constituents or impurities can naturally make the briquetting difficult or quite prohibit it. This specially applies to pyrites, which often occurs lumpy, in streaks, or distributed uniformly in the fine state, and also to sand, which is principally met with in the upper layers of the earthy lignites. Even a moderate content of pyrites can act dangerously, since its partial decomposition can give rise to fires during the drying of the coal on account of the inflammability of coal dust. Further, briquettes prepared from such coal are not weather-proof, and during combustion are very objectionable because of the evolution of obnoxious gases. Above all, pyrites and sand wear out the press stamps and moulds.

Consequently, coarse pyrites must under all circumstances be removed or sorted out mechanically. Particles of coal containing much finely divided pyrites or sand must be excluded from briquetting and delivered direct to the boiler-house.

Experimental Briquetting Stations.—In order to determine the adaptability to briquetting, it is recommended that large quantities of coal (at least several double loads of 10 tons) of the average composition of the brown-coal source should be subjected to practical tests in a briquette factory or an experimental briquetting station. Such experimental plants as those of the Zeitzer Eisengieszerei und Masch. Akt.-Ges. in Zeitz, of the Maschinenfabrik Buckau at Magdeburg-Buckau, and similar works offer the especial advantages that suitable mechanical appliances, etc., can be worked out for the particular case in view.

C USUAL METHOD OF BROWN-COAL BRIQUETTING

The customary method practised in Germany is briefly as follows. The brown coal is got either in open workings after a preliminary removal of the covering soil, or in deep workings, i.e. by underground mining operations, mostly with picks, and transferred to the briquette factory in conveyor waggons drawn up a rising track by means of chain or less often wire conveyors, or in suspended tipping buckets operated by a wire-rope way. The briquette factory is as a rule quite close to the mine itself, close to the workings, or is connected up with the railway.

Here the crude, pit-moist coal is first handed over to the wet operations, prepared by mechanical coarse and fine grinding combined with repeated sieving, and separated, on the one hand, into boiler and burning fuel, which contains as far as possible all the impure coal unsuitable for briquetting, the coarse pieces of brown coal, pieces of wood, and other foreign materials; on the other hand, into briquetting coal of medium fine grained and meal. The first passes to the boiler house, while the briquetting coal passes on to the coal floor of the drying plant, where it proceeds to the drying appliances arranged below and heated for the most part by waste and fresh steam. Here it is dried to the extent necessary for the production of good briquettes (down to a content of 12 to 17 per cent. residual water). The dried hot coal has to be mixed, cooled, and finally pressed either to domestic or industrial briquettes, which are pushed to the railway waggons or storage-place down long iron gutters.

The coal dust which is copiously developed during the continual to-and-fro motion while drying and compression is led to suitable dust catchers and made safe, or led back to the presses, in order to prevent dangers from fire and explosions and the covering of surrounding objects when the dust is blown about.

D. MINE INSPECTION REGULATIONS.

The relatively great danger of the brown-coal briquetting industry and the ease with which the surroundings become covered with dust from such operations induced the various German states and district Governments concerned to issue mine inspection regulations ten years ago. As an example, only the "Bergpolizeiverordnung fur die Braunkoklenbrikettfabriken im Verwaltungsbezirk des Kgl. Oberbergamts zu Halle a. S.," of 21st December 1903, prescribed for the largest Prussian and German brown-coal district, will be dealt with here.

The order contains stringent regulations on :—

I. Installation and appliances of the factory (method of operation, distance of the factory from buildings, construction of the factory, prevention of the accumulation of coal dust, protection from the ignition of coal dust, prevention of the spread of fire, signalling appliances, illumination, application of high-tension electric current, workers' rooms and bathing appliances, special safety appliances in existing factories.

II. Operation of the factories (setting in operation, illumination, removal of coal dust, precaution against risks of fire, repression of fires, indications of explosions, special safety appliances, workers).

III. Special regulations for the factories with fire-heated and hot-air drying arrangements.

IV. Penalties.

V. Final instructions.

The pertinent mine inspection regulations of the remaining Prussian mining bodies concerned, as well as the mining authorities of the kingdom of Saxony, state of Thuringia, etc., are in complete general agreement. The dispensation and stringent execution of the regulations of the mining authorities have without doubt led to a considerably better condition, as compared with earlier times, with regard to the safety of working as well as the protection of public interests; on the other hand, however, it must be taken into account that the operation of the numerous regulations demand continual close attention on the part of the owner of a plant in operation which will diminish the economical results by not an inconsiderable amount, more especially in the case of small works.

SECTION II.

PROPERTIES OF BROWN-COAL BRIQUETTES.

A. SHAPE, SIZE, AND WEIGHT

THE various kinds of brown-coal briquettes are almost wholly prepared by means of the Exter rope press, in which a horizontal press stamp moves backwards and forwards in an open channel-shaped mould (see Section VI) With regard to choice of shape, size, and weight of the individual briquettes, the remarks given in the case of coal briquettes (Section I, Part I) generally apply equally well here The determining factors are the object of application the special conditions of transport, storage and firing and of course the economy of the pressing operations

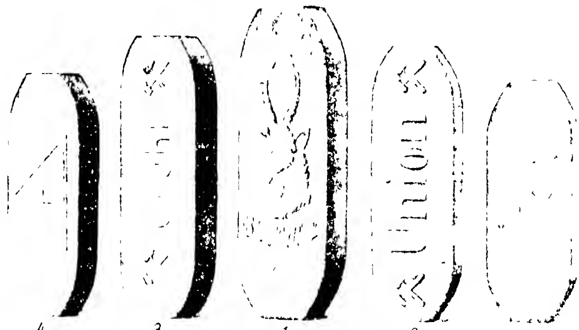
Naturally, as distinguished from the coal briquettes brown-coal briquettes find very little application on railways and on ships, because of their considerably lower calorific value. This is excluding the railway sidings service at the mines and factory railways They are used above all as domestic fuels for the heating of rooms and kitchen ranges, and of late in steadily increasing circles as small industrial briquettes for firing in many industrial and commercial operations The production of larger, heavier, compressed blocks would be quite unsuitable for the objects named Further, no consideration is given to the highest possible utilisation of limited storage space in the choice of shapes

I DOMESTIC BRIQUETTES

Requirements.—Domestic briquettes must be of such dimensions that they can be laid by hand conveniently in the grate and piled up piece by piece, without requiring a preliminary breaking Further, it is to be desired that the individual briquettes are of equal size, and as far as possible are intact so that the orders and use can be regulated and determined simply according to number

They must allow of close storage, long rail transport, and of undergoing frequent loadings without breaking or crumbling at the edges. Since the briquettes give off vapour after leaving the presses, sufficient interspaces must be left on storing to permit of the evolution of steam and to allow of cooling.

These various requirements are taken into account in the usual shapes: there are long flat briquettes whose broad sides—apart from the manufacturing marks pressed into them—with the short narrow sides are flat, and whose long narrow sides are convex (figs. 107 and 108, Nos. 1 to 5, and fig. 109, Nos. 1 to 4). As a result of this convexity, there are formed, when the briquettes are standing or lying on each other in railway waggons or stores, corresponding channels between



4 3 1 2 5

FIG. 107.—Six-, seven-, and eight-inch domestic brown coal briquettes of various origin.

the horizontal or vertical series which amply fulfil the described object. In addition, the edges of the ends are protected to a certain extent.

With regard to the shape and degree of convexity, the samples of briquettes from the various factories show more or less considerable variations, so that even with the same breadth in the middle, equal length, and thickness, different cubic contents and weights are exhibited.

Many samples of briquettes are rounded off at the ends much more than necessity and suitability demands, the result being that the available section of the press is not utilised to its full advantage.

The briquettes represented in fig. 108, Nos. 1 to 6, are the general shapes, which show considerable variations. No. 6 shows two round humps on one of the broad faces and two corresponding grooves on the other face, while No. 7 shows round indentations in the middle of each of the long narrow sides.

In both cases central channels are formed between the briquettes when they are laid on each other in the manner depicted. This provides free passage of air in the grate and causes the briquettes to ignite rapidly and burn completely. In view, however, of the ease with which brown-coal briquettes ignite and their high content of oxygen

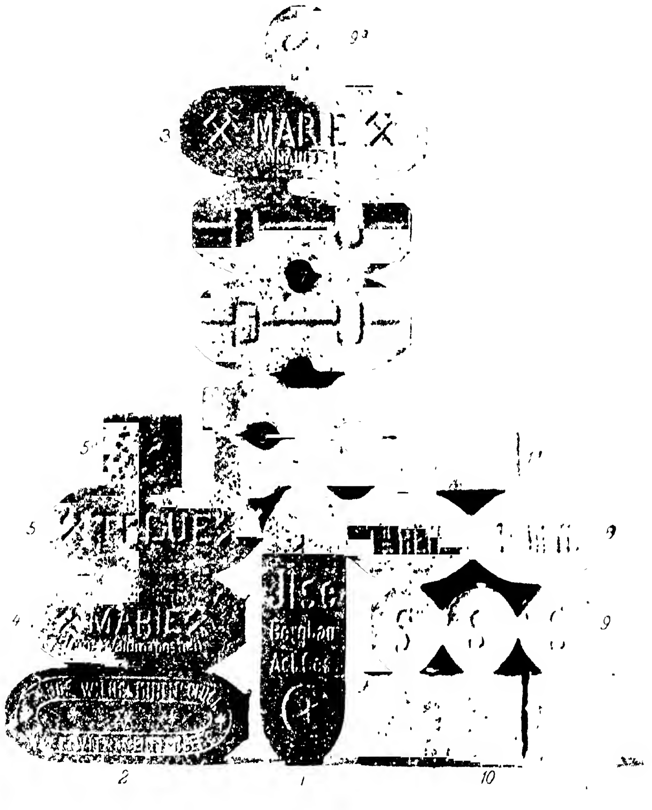


FIG. 108.—Various domestic and industrial brown-coal briquettes.
(From the Briquette Collection of the Kgl. Bergakademie at Berlin.)

such artificial aids appear to be unnecessary, particularly as they are accompanied by not unimportant disadvantages, such as premature crumbling during combustion, expensive production and repairs of the press stamps and moulds, and, in the case of No. 7, incomplete utilisation of the area of the press. Consequently, these and similar brands have made but little headway.

With regard to size, domestic briquettes of the ordinary shapes have from the beginning been generally distinguished as 6-inch

7-inch, and 8-inch blocks (fig. 107, Nos. 1 to 5), in which only the principal dimension, length (6-inch = 152 mm, 7-inch = 186 mm, 8-inch = 201 mm.), is taken into account

The average breadth or height amounts to 60 mm. in the 6-inch blocks, and 60 to 63 and 65 to 68 mm. respectively in the 7-inch and 8-inch blocks, the thickness varies even in one and the same brand of briquette, but as a general rule lies between 30 and 40 mm

The measurements and weights generally taken as normal of these forms, together with the number in a hundredweight as well as in a railway double load (200 cwt = 10 tons), are given in the following table

	6-in. Briquettes.		7 in Briquettes. Ordinary	7 in Briquettes. Pound Briquettes	8 in. Briquettes
Length .	158 mm		186 mm	186 mm	210 mm.
Average breadth .	60 ,,		60 ,,	63 ,,	68 ,,
Thickness .	32 mm	35 mm	35 ,,	10 ,,	35 ,,
Weight .	326 grm	360 grm.	155 grm	500 grm	520 grm
Number per cwt	153	140	110	100	96
Number per double load	30,600	28,000	22,000	20,000	19,200

But the normal dimensions given are not always adhered to; greater or less variations can very often be made, particularly in the thickness, and specially in the 6 inch and ordinary 7-inch briquettes. The origin of the variations is to be sought, partly in the nature of the working of the press—as a result of rapid deterioration, frequent change and renewal of the moulds, occasional irregularities in the introduction and compression of the briquetting mass—and also in the not unusual but objectional business methods of many coal merchants, who turn the user's custom of ordering the domestic briquettes by number and not according to weight to their own advantage in such a way that in their orders to the briquette factories concerned the delivery of briquettes of narrower profile or, what is more usual, of less thickness, is prescribed They themselves order and pay for the briquettes by weight in waggons of "double loads" (10 tons), but in turn retail the briquettes by number from each double load, and thus obtain a larger number of briquettes than would be obtained in the case of normal measurements As to prices, these either remain the same or are not very much lower, and never in proportion to the lower weight provided. For example, a double load of 6 inch briquettes of

normal length and breadth contains 33000 blocks of only 30 mm thickness and 34000 to 35000 of only 28 to 29 mm thickness so that 2400 or even 3400 to 4400 more briquettes can be sold than is the case with the normal thickness of 32 mm

It is well known that consumers do not observe the imposition because of ignorance of the normal dimensions and weights As a result the active interests of certain large briquette factories and later of certain selling agencies, have led to many users buying their briquettes accord-

FIG. 109 Various brown-coal domestic and industrial briquettes
(From the Briquette Collection of the Kgl Bergakademie at Berlin)

ing to weight, the quantities of briquettes ordered being delivered directly from the selling works themselves or from the middlemen in lead-sealed sacks when desired for the purpose of control The sacks contain a definite weight usually 1 cwt.

The Rhenish brown-coal industry had adopted another apparently good method for the protection of the public, because their works in 1898–99 took up the production of somewhat large 7 inch briquettes weighing 1 lb and known as 'pound briquettes' [1] (see above table) In

[1] Sechster, *Jahresbericht des Vereins für die Interessen der Rheinischen Braunkohlenindustrie*, from 1st July 1898 to 30th June 1899

this way users have the advantage in small purchases of readily obtaining the briquettes according to number, getting the correct weight, and not being imposed upon with regard to price. Then the purchase according to number for a small sum will be of great importance, especially to the small user, in determining the preference for briquettes. However, it is unfortunate that it is not always technically practicable to obtain briquettes of exactly equal weight, for the reasons given above (see p 288) Consequently, there has been a movement of late in this district to do away with selling of briquettes by number. Meanwhile, the much-discussed proposal that fuels should only be sold by weight, according to regulations enforced by law, appears to be unsuitable, since it would lead to an uncalled-for police interference with the retail of briquettes which could not, in any case, be completely successful in its object.

The "pound" and other 7-inch briquettes are the sizes most in demand for domestic fuels. They, and the first-named especially, last considerably longer than the 6-inch briquettes in a slow fire, adapt themselves better to heating in suitable slow-combustion stoves and in addition their manufacture is of greater economic advantage to the briquette factory. The 6-inch briquettes are, however, produced in considerable quantities for certain spheres of utility especially in Central Germany.

Several years ago the by-production of 8-inch briquettes (fig 108, No. 1) was taken up by two large works in the Niederlausitz These blocks were supplied mainly to railway authorities for heating rooms on the line and to the railway officials' associations at reasonable prices They have not been adopted as house fuels, since they are too large.

In recent times, at the "Phonix" briquette factory, for example, there have been produced domestic briquettes of more cylindrical shape, which have a length of 102 mm., a depth of 70 mm. at the middle and 38 mm. at the narrow ends, a width of 25 mm, and a weight of 415 grms. They occupy a position between the 6- and 7-inch briquettes.

Further information on the most suitable method of heating with domestic briquettes is given in Section XII.

II. Industrial Briquettes.

Industrial briquettes may find applications in large and small manufacturing operations for firing boilers or the production of heat for various purposes, in the generation of suction producer-gas for the

development of heat or power (in gas engines), in the place of other materials formerly used for the same purpose, more especially coal and the high-priced North-west Bohemian lignites, and in certain industries, *e.g.* bakeries, instead of wood. For most of these purposes the briquettes are provided in much smaller sizes than the domestic fuels, similar to the rough coals (small lumps, cubes, and nuts) otherwise applied. In order to obtain a more or less rapid development of the heat required, a condition which is so highly desirable, a very large surface must be offered to the action of the atmosphere introduced by the suction of the chimney or similar means.

With regard to the degree of fineness of the individual briquettes, there is no need to go so far as in the case of coals, because of the high oxygen content of the lignite. As far as possible, the choice of shape for the purpose of boiler firing is to be made so that they do not form unnecessary large inter air-spaces when lying upon and close to each other on the grate and lead to incomplete combustion.

The usual varieties of industrial briquettes are generally divided into "half-brick," "cubical," and "nut" briquettes. In addition, there are still many special angular or round shapes, which will be dealt with later.

The manufacture of half bricks began by pressing domestic briquettes with an upper and lower indentation in the centre (see fig. 108, No. 8, and fig. 109, No. 5), which are cut through the weakest place by means of a cutting appliance before loading into the railway waggons.

Half bricks approaching a circular shape are still produced at many works. Later, in order to utilise the full section of the press more completely while still retaining the central indentations, the production of briquettes of special large shapes having the narrow sides the full width has been taken up. From these it is easy to obtain rectangular briquettes with sharp edges for ready ignition. These briquettes are then broken through mechanically—not cut through—producing the half bricks, as shown in fig. 109, No. 6 (Th. Heye). Then followed the production of finished half bricks by the use of a stepped stamp. These had smooth faces even on the short narrow sides (see fig. 109, Nos. 7 and 8, and fig. 110, No. 7), thus obviating the use of special cutting and breaking arrangements. They give less waste and dust than the half bricks with rough fractures (fig. 109, No. 2), but the latter, on the other hand, give the advantage of a more rapid ignition.

Since the method in vogue for stacking domestic briquettes, *i.e.* in regular rows, is also adopted for the storage of half bricks and other industrial briquettes the rounding off which the semi-stones still show at one end appears to be superfluous, because of the possible formation of evaporation and cooling channels. Their retention is based on the fact that the semi-stones allow themselves to be more easily removed by means of the coal shovel and fork because of the rounded surfaces. Further, they do not lie so close on the grates, and therefore permit of a better circulation of air than with the cubical briquettes.

In more recent times quite rectangular half bricks of the shape

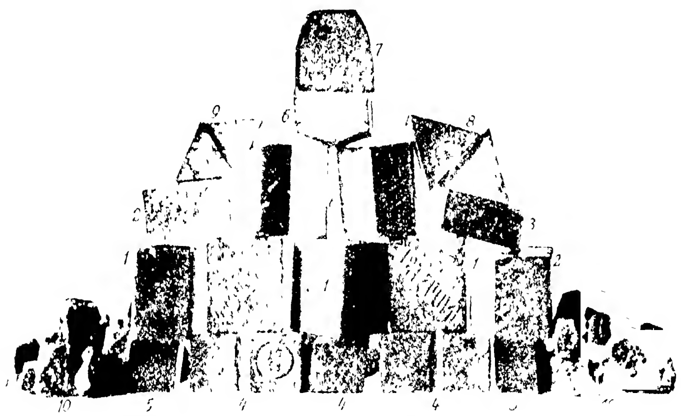


FIG. 110. Various samples of small industrial briquettes.
(From the Briquette Collection of the Kgl. Bergakademie at Berlin.)

of large flattened cubes (77 × 72 × 48 mm., weight 362 grm.) are prepared in places. These might be called cubical briquettes. However, the industrial briquettes, whose sizes and weights lie between those of half bricks and nut briquettes, are usually understood under this name.

The weight of the individual semi-stones (separated from each other) varies between about 240 and 360 grm. according to their size and shape.

Cubical briquettes are the shape of flattened cubes with quadratic broad sides and sharp rectangular edges. By means of a horizontal stamp of long rectangular section, whose pressure surface is divided by means of central projections (nose) into three equal quadratic parts arranged next to each other step-wise, three cubical briquettes

are produced simultaneously at each stroke against the last pressed briquette.

Therefore by this method of production the central briquette is only pressed against the two outside briquettes during the following stroke. In this way there are produced between the individual blocks of the same series semi-smooth division faces by means of which the briquettes become separated from each other simply by falling from the conveying channel into the railway waggon. Fig. 108, No. 10 shows three such cubical briquettes taken from the channel. Two of them, with the outstanding press fins clearly shown, still hold together. Fig. 110, Nos. 1 and 2, shows some larger more marketable brands of cubical briquettes.

Most of the brands of "nut" briquettes are nothing more than small cubical briquettes and are as a rule prepared in exactly the same manner, by the use of double-stepped press stamps on each side. In this way five nut briquettes are prepared simultaneously with every stroke, and between the individual blocks of the same series four division faces are always formed. With the same sectional area of press stamp for cube and nut briquettes, and with equal width of both varieties, there are formed briquettes whose height, width and breadth stand in decreasing relationship with each other (fig. 109, No. 9, and fig. 110, Nos. 4 and 5). But the differences of length are not considerable, so that the nuts approach nearer than the flat cubical briquettes to the correct cubical form.

Peculiar shaped rounded nuts in the form of short cylinders, as shown in fig. 108, Nos. 9 and 9*a*, are prepared in the Sollinger Forest at Volpriehausen (Hannover) as domestic briquettes in the form of three stones holding together like a triple sectioned roll. Corresponding moulds and stamps are used, and the briquettes are subsequently separated into the individual pieces by means of knife cutters. A similar method is in operation at the new Kraft briquette factory, where six adhering briquettes of a total length of 6 × 42 mm., height of 60 mm., thickness of 36 mm., and total weight of 650 grm., are produced simultaneously with each stroke.

In addition to the samples and methods for nut briquettes already dealt with, there is still another series of which more will be said in Section VI. under the heading "Stamps and Moulds for Small Briquettes." Fig. 110, No. 6, shows a swallow tailed and Nos. 8 and 9 triangular prismatic briquettes, while No. 10 shows "broken briquettes" such as are obtained by Venator's method in which plate-shaped

briquettes are broken up mechanically in order to obtain small stones with, for the most part, irregular, rough, or angular surfaces somewhat after the nature of coal nuts

B. SPECIFIC GRAVITY.

The specific gravity or density of the briquettes averages about 1 2. Naturally it is correspondingly increased by lower water content, higher ash content, and higher pressure, and decreased by the opposite factors

C. EXTERNAL APPEARANCES.

Good domestic briquettes have on all sides a smooth, neat surface, so that they can be picked up without soiling the hand A striking difference exists, however, between the appearance and properties of the narrow and broad sides The broad sides are, as a rule, matt, lustreless, and dark brown, apparently passing gradually into a fine black, fused crust at the edges (see figs 107 to 109), the trade or briquette mark is raised in clear, rounded letters or signs on the front side and impressed in the back

The narrow sides (friction sides), corresponding to the walls of the press mould, forming the surface of the fused crust are, however, lustrous black, and are usually covered in the direction of pressing with fine ripples, which can scarcely be felt In addition, the upper narrow sides show numerous scratches running irregularly, and between them are smooth elevations of the fused crust, which can scarcely be felt. The lower sides do not exhibit the phenomena to anything like the same extent, and usually show much less lustre

At the same time, industrial briquettes show on the sides which have been against certain parts of the walls of the press moulds a black, lustrous, finely rippled fusion crust The parts of the sides which have surfaces produced against the stepped press stamps, as well as the corresponding sides of the stone of the same series pressed immediately afterwards and forming the division surfaces described above (p. 293), show less fusion and lustre, are often somewhat rough, and affected by the unbaked particles of the neighbouring briquettes, more especially on the edges

While great value is placed on a surface as free as possible from faults, and especially on an undamaged crust in the case of room briquettes, there is obviously much less stress laid on this point for

industrial briquettes, which are bought at a much cheaper rate A further discussion of the various surface properties of good and faulty briquettes is entered into later under Section VI

D. STRENGTH.

As a rule, the requirements as regards strength in lignite briquettes are similar to those demanded in coal briquettes Domestic briquettes as a whole should be capable of being delivered to the households in distant towns in whole smooth blocks, with as little damage as possible, even on the edges For this purpose they require careful and considerate handling, they must not be allowed to fall or be thrown during loading on the railway waggons or the like, and also during loading, unloading, storage, intermediate deliveries, and final deliveries at the place where they are to be used They must therefore be strong enough to resist the unavoidable shakings during transport by rail and progress along rough roads, they must also, if it becomes necessary through lack of sales or other deficiencies, be capable of remaining stored for long periods in spaces with light coverings, or even in the open, or of being stacked in large heaps without seriously suffering in strength through the influences of the weather (damp, cold, heat), and without giving much waste Industrial briquettes are affected in quite another way Loading, unloading and reloading are not effected by hand Usually the briquettes are allowed to fall from the briquette gutter, which is a continuation of the press channel, directly into the railway waggons, or, in the case of working on stock, into the factory yard or on to the slope of the briquette heap, so that they can be thrown into the vehicle by means of a coal fork or shovel during subsequent loading. The further handling of industrial briquettes is carried out in the same or similar rough manner up to the time of their use The user does not demand a faultless exterior, but he requires them to be delivered in whole pieces with as little as possible waste slack and dust, which is to all intents and purposes useless.

Testing for Strength —It is customary to test domestic briquettes for strength—without the application of a compression machine and regard to numerous results—simply by taking the briquette in both hands and trying to break it across the middle of the broad sides If this does not succeed, it is laid flat on the knee and fracture is attempted by strongly pressing on either side, or it is struck on the edge of a table, and so on. The greater or less resistance which the briquette offers to

these experiments—and of course the thickness of the briquette is to be taken into account—gives to the experienced the most important indications, in conjunction with the appearance of the surface and the fresh fracture, as to the quality of the product. Good briquettes of normal thickness can scarcely be broken simply in the hands even of a powerful man; stones of the best quality also resist the knee test.

The fracture of good briquettes (compare fig. 108, Nos. 1*a*, 5*a*) is jagged, showing fine and coarse grains uniformly distributed, and dark brown to almost black in colour. Here and there are to be seen black, more or less lustrous streaks, veins, or lamellæ having the appearance of a solidified melt, and distributed through the mass there are numerous fine points of similar appearance, which can be seen better with a lens. Thin sections give only an obscure view of the structure under the microscope.

The regular production of the necessary strength on a working scale without the application of a special binding material is the main secret of brown-coal briquetting. A series of factors must work together with this object: suitable chemical composition of the crude coal, proper granulation, particularly correct ratio of the quantity of pieces of coal to the dust, definite and not excessive drying of the coal, sufficient cooling of the dried coal, good properties and nature of the coal adapted to the arrangement of the press moulds and stamps, corresponding degree of pressure, correct temperature of pressing, and so on—factors which will be dealt with more completely in the following sections.

E. CHEMICAL COMPOSITION. CALORIFIC VALUE.

The chemical composition of brown-coal briquettes is naturally dependent in the first place on that of the constituent brown coals, and in the second place on the degree of drying. If a special binding material has been added to brown coals which—such as, for example, those of the North-west Bohemian main district—are not capable of being briquetted by themselves, the chemical composition of the resulting briquettes is obviously influenced to a corresponding extent.

In the following table are collected the results of a number of old and recent analyses, along with the calorific values, determined calorimetrically, of German brown-coal briquettes and their places of production.

Origin	Water	Ash	Carbon	Hydrogen	Oxygen and Nitrogen	Sulphur	Total of Combustible Constituents	Calorific Value in cals per kg: Calculated from the Analysis	Calorific Value in cals per kg: Determined in the Calorimeter	
				NIEDERLAUSITZ						
	per cent	per cent	per cent	per cent	per cent	per cent.	per cent			
Niederlausitz	11·26	5·25	54·57	4·18	23·90	0·89	83·49	4739	4744	
"	10·51	4·17	54·63	4·21	25·42	1·05	85·29	4704	4764	
Bockwitz { industrial briquettes	14·35	4·48					81·17		4701	
Groszräschen	12·66	4·19	55·01	4·21	22·90	1·00	83·15			N 0·63
"	16·70	3·90	53·45	3·89	22·06 including sulphur		79·40			
				KINGDOM OF SAXONY AND ALTENBURG						
Borna Lobstädt	14·43	8·80					76·77			
Meuselwitz	14·81	10·76					74·43		4929	According to H. Langbein
Rositz	14·88	6·19					78·93		4900	"
"	14·17	[illegible]					78·17		4872	"
"	15·95	8·42	51·73	4·25	19·12	0·53	75·63		4807	
Mellus	16·30	8·71					74·99		4734	According to H. Langbein
				PROVINCE OF SAXONY AND BRUNSWICK						
Nachterstedt	16·38	7·72	54·33	4·50	17·07		75·90			
Harbke	15·60	7·11	55·25	3·48	18·56		77·29			
Offleben	19·76	8·22	45·38	3·72	22·92		72·02			
				BROWN COAL DISTRICT OF CENTRAL GERMANY.[1]						
Pit a	11·37	6·07	54·89	4·63	22·03	0·99		4832		
" b	10·11	8·74	49·60	3·90	27·65			4085		
" c	11·94	5·72	51·84	3·86	21·73	0·91		4163		
" d	10·05	5·40	56·31	4·44	21·70	0·47		5011		
" e	13·81	6·18	53·33	4·24	20·99	0·45		4718		
" f	12·00	7·62	52·12	4·39	22·49	0·48		4620		
" g	11·20	9·02	52·81	4·03	21·23	0·71		4629		
Average of many analyses of briquettes from Central Germany	12·90	5·88	54·43	4·40	21·71	0·68	81·22		4880	
				LOWER RHINELAND						
Bruhl	17·85	4·66	53·50	3·90	20·09	0·16	77·49			
"	16·57	6·69	52·14	3·61	20·99	0·11	76·74			

It will be seen from the above table that the differences of chemical composition in the brands of briquettes analysed are not considerable, especially if some few brands (especially 14 and 16, which are apparently

[1] *Z. Braunkohle*, 1902, No. 39, p. 466. The calorific values are calculated from the formula given by the Verbande der Deutschen Dampfkesselüberwachungsvereine ("Verbandsformel").

exceptions) are disregarded. Then the following limiting values are obtained :—

Carbon	52·0 to 56·0 per cent.	(approx.)	
Hydrogen	3·5 „ 4·5 „	„	
Oxygen and nitrogen	17 „ 25 „	(usually above 20 %)	
(Nitrogen is always below 1 per cent.)			
Sulphur	0·1 to 1·0 per cent.		
Total combustible matter	75 „ 85 „		
Ash	4 „ 10 „		
Water	10·5 „ 18 „		

The high oxygen content usually amounting to over 20 per cent., is characteristic, and, as will be shown later, is of special importance in the firing of brown coals. The very low content of sulphur appears to be very favourable. At the same time, the ash content is often very low, and even in the impure brands maintains a moderate limit.

With regard to the calorific value, the following remarks may be added here to the general observations on the theoretical and calorimetric methods of determination dealt with in Part I. of this book (p. 16 *et seq.*). Values for the theoretical calorific value which have been calculated from one or another of the various formulæ on the basis of the elementary analysis are always more or less inaccurate. However, a greater degree of accuracy is obtained in the calorimetric heating values, calculated from the "heats of combustion" determined in a calorimetric bomb, by subtracting the heat of evaporation. The calorimetric heating values given in the foregoing table vary between about 4700 and 4930 cals. Dr. H. Langbein[1] has obtained calorific values of 4491, 4588, 4614, 4627, 4663, 4701, 4724, 4816, 4907, 4954 cals. for a series of Niederlausitz briquettes which he has tested. According to the same authority, the Niederlausitz briquette is always and not inconsiderably outclassed by the Saxon if the moisture and ash contents are the same, since the older lignites of the province and kingdom of Saxony, along with Altenburg, show a higher content of carbon and hydrogen in the pure coal. They yield, therefore, a number of brands of briquettes giving a calorific value exceeding 5000 cals. In his comparative collection of calorific values of various fuels (see above, p. 19) Dr. Langbein gives a limiting value of 4600 to 5400 calories for lignite briquettes.

Chief-Engineer Neuman[2] has obtained the following limiting values

[1] *Z. Braunkohle*, 1902, No. 39, p. 465.
[2] Gluckauf, Essen, 1906, No. 31.

for the water, ash, and combustible matter contents of Saxon, Lausitz and Rhenish brown coals on the one hand, and Saxon, Rhenish and Bohemian briquettes on the other:—

	Water	Ash	Combustibles: Solid Carbon	Combustibles: Volatile Constituents	Combustibles: Total	Calorific Value
Crude Brown Coals.						
	per cent	per cent	per cent	per cent	per cent	Cals. per kg
Saxon coal	12-56	2-10	11-21	27-30	38-51	2200-3200
Lausitz ,,	46-58	2-7	19-29	21-24	40-53	2000-2700
Rhenish ,,	52-60	2-4	18-23	20-27	38-50	2100-2400
Brown Coal Briquettes.						
Saxon briquettes	11-18	7-11	32-39	42-45	74-84	4500-5000
Lausitz ,,	13-17	4-6	37-40	40-43	77-83	4600-5200
Rhenish ,,	18-36	2-8	32-35	35-40	65-75	4000-5600

The Bohemian briquettes of this table come principally from the district of Königsberg on Eger, where a very damp coal of an earthy nature similar to a Central German brown coal is obtained, and also briquetted without the use of a binding material.

Since the brown coal briquettes of Lausitz and Saxony often come into sharp competition with the good lumps of brown coal from North-west Bohemia, the following collection of experimental results on Bohemian brown coals of various origin, which have been obtained almost wholly by Dr H. Langbein, will be of special interest:—

BOHEMIAN BROWN COALS.

Origin	Water	Ash	Total Combustible Constituents	Calorific Value (determined calorimetrically)
	per cent	per cent.	per cent	Cals. per kg
Falkenau	39.97	5.57	54.52	3619
Königsberg on Eger	41.30	3.30	55.40	
,, ,,	47.97	3.17	49.31	
Neusattl (gas coal)	14.60	4.50	81.64	
,, ,, ,,	29.99	7.18	62.83	4561
Eisenberg	33.23	6.02	60.75	4127
,,	22.91	3.09	74.00	4989
Brüx	23.00	4.32	72.68	4984
,,	26.51	5.72	67.77	4725
Wiesa	27.13	3.89	68.98	4755
,,	21.35	3.28	75.37	5147
Ossegg	24.80	5.28	69.92	4927
,,	19.90	2.55	77.55	5516
Dux	36.56	3.21	60.23	4013
,,	23.35	5.14	71.51	
Mariascheim	21.80	1.37	73.93	4674

Further, the results of experiments on the composition and calorific value of a number of German and Bohemian brown coals and German brown-coal briquettes are given below The results of the calorific values refer to the pure coal as suggested by Mohr[1] (p. 272).

Brown Coals

Consecutive No.	Origin and Description of Fuel	Water	Ash	Pure Coal.	Sulphur.	Calorific Value in Cals per kg — Corrected	Calorimetric	Calculated to Pure Coal
		per cent.	per cent	per cent.	per cent			
1	Clettwitz coal, air dried	37·18	6·67	56·15		3011	3403	6061
2	,, briquette coal, ,,	31·38	5·27	63·35	0·92	3511	3871	6110
3	,, upper coal, ,,	37·41	5·30	57·26		3176	3559	6216
4	Senftenberg, ,,	36·50	5·06	58·44		3283	3668	6277
	,, moist	54·56	3·62	41·82	.	2178		
5	Konsol. Gnadenreich bei Petersdorf, large coal brand . .	36·15	4·89	58·96	...	3341	3730	6323
	Do., moist	45·75	4·15	50·10		2749	.	
6	Konsol. Blitz bei Wrietzen	20·25	6·92	72·83		4358	4675	6119
	Do., moist . . .	52·14	4·15	43·71		2275		
7	Konsol. Gnadenreich bei Petersdorf, rough coal brand	38·84	5·26	55·90		3202	3592	6426
	Do., moist .	48·75	4·41	46·84		2586		
8	Province of Saxony . . .	34·29	14·42	51·29	1·08	3152	3493	6434
	Do., moist	46·84	9·24	43·91	...	2438	..	
9	Konsol. Gnadenreich bei Petersdorf, slack coal brand	39·23	8·60	52·17		3051	3437	6588
	Do., moist	52·03	6·79	41·18		2282		
10	Bitterfeld .	35·50	7·78	56·72	2·75	3185	3869	6821
	Do., moist	49·82	6·05	44·13	2·11	2538		
11	Province of Saxony	47·31	6·78	45·91		2812		7039
12	Leopold pit at Edderitz	45·11	6·05	48·84		3107		7299
13	Bohemia, Brux	28·47	8·43	63·10		4257	4621	7323
14	Bohemia . .	31·90	7·57	60·53		4219	4579	7563
15	Province of Saxony	24·42	8·07	67·51	1·55	4826	5154	7634
16	Bohemia	24·04	7·24	68·72		4937	5314	7733

Brown-Coal Briquettes.

Consecutive No.	Origin and Description of Fuel	Water	Ash	Pure Coal.	Sulphur.	Corrected	Calorimetric	Calculated to Pure Coal
1	Briquette M .	7·15	5·61	87·24		4756	5081	5824
2	Germania briquette . .	12·36	6·46	81·18	1·00	4519	4859	5986
3	Marie briquette, Alwine pit at Costebran . . .	11·54	6·43	82·03	1·02	4628	4922	6000
4	Marie briquette, Raschen . .	14·46	5·19	80·35	0·42	4507	4825	6005
5	Ilse small cube briquette .	10·28	6·16	83·56	0·61	4707	5019	6006
6	T brand . . .	10·67	6·49	82·84	1·12	4693	4997	6032
7	Beutersitzer industrial cube briquette	16·02	7·99	75·99	1·08	4308	4613	6070
8	Ilse broken briquette . .	14·41	4·46	81·13		4791	5111	6079
9	Th. Heye briquette . . .	12·46	5·75	81·79		4681	4998	6111
10	G. L. brand briquettes .	15·90	7·42	76·68	1·42	4366	4691	6118

[1] Mohr, "Feuerungstechnische Untersuchungen und deren Bedeutung für die Praxis" (Berlin, Institut für Gärungsgewerbe), see also *Z. Braunkohle*, 1906, No. 24, p. 382.

BROWN COAL BRIQUETTES (*Contd.*)

Consecutive No.	Origin and Description of Fuel	Water	Ash	Pure Coal	Sulphur	Calorific Value in Cals per kg Corrected	Calorimetric	Calculated to Pure Coal
		per cent	per cent	per cent	per cent			
11	Friedrich Wilhelm I Mine, Costebrau .	12.63	6.96	80.41	0.59	4603	4925	6125
12	W cube briquette completely volatilised	12.79	6.38	80.83		4658	4952	6126
13	Berggeist room briquette	13.53	6.78	79.69		4571	4888	6134
14	Brand T .	12.85	5.64	81.51	0.85	4708	5021	6160
15	Clara, Welzow, Anker	13.24	4.95	81.81	0.72	4736	5051	6171
16	Industrial briquette	12.04	5.99	81.97	0.75	4747	5066	6177
17	Kaiser briquette .	16.01	4.73	79.26		4578	4901	6183
18	Ilse industrial briquette	11.49	8.06	80.45		4678	4985	6196
19	Marie briquette, Mariannens Gluck	10.90	6.31	82.79	0.90	4821	5135	6202
20	Briquette S .	12.52	7.92	79.56	1.10	4678	4939	6208
21	Marie briquette, Mariannens Gluck	10.71	6.66	82.60		4876	5136	6218
22	Cube briquette	12.17	6.54	81.29	0.64	4757	5056	6220
23	Mariannens Gluck	9.49	6.59	83.92		4900	5228	6230
24	Syrilla briquette	13.58	6.15	80.27		4690	5005	6235
25	Bockwitz industrial briquette .	15.17	4.00	80.83		4723	5051	6249
26	Kaiser briquette	15.77	5.95	78.28	0.94	4567	4895	6253
27	Anna room briquette	14.09	6.77	79.14	0.94	4634	4958	6265
28	Kaiser briquette	13.79	5.68	80.53		4757	5068	6293
29	Berggeist industrial briquette, S brand	9.86	10.07	80.07	1.55	4754	5050	6307
30	Germania briquette	13.87	4.81	81.32		4804	5135	6315
31	Poley briquette	11.39	6.82	81.79		4862	5147	6326
32	Friedrich Wilhelm I Mine, Costebrau . .	13.76	7.30	78.94	1.00	4690	5012	6349
33	Ida briquette . .	16.68	6.84	76.48		4593	4902	6409
34	Berggeist briquette, S brand .	13.79	7.46	78.75	1.64	4758	5051	6414
35	Fine briquette	12.96	9.55	77.49	2.00	4690	4999	6451
36	Caroline briquette	13.81	12.83	73.36	3.88	4650	4862	6628
37	Sporn briquette	12.45	8.90	78.65		4969	5281	6715
38	N K briquette, Naumburg	12.72	9.49	77.79	2.51	4973	5294	6806
39	B & Co briquette, Weissenfels	14.85	10.10	75.05	2.53	4887	5231	6916

It follows from the foregoing table that the German brown-coal briquettes, mainly as a result of their lower content of water, even exceed the better Bohemian brown coals as regards calorific value. A series of the very good brands are about on the same plane and are only slightly inferior to a few of the very best Bohemian coals.

The calorimetric heating values of the brown-coal briquettes dealt with in the last table vary between 4600 and 5300 calories, but in by far the greatest proportion of them the value is over 4900, and in more than half of the samples the value is over 5000 calories.

The water content of these briquettes varies between 7 and 16.7

per cent, the ash content between 4 and 12·8 per cent., but only seven brands contain more than 8 per cent. Six of these briquettes contain over 1·5 per cent. (up to 3·88 per cent.) of sulphur.

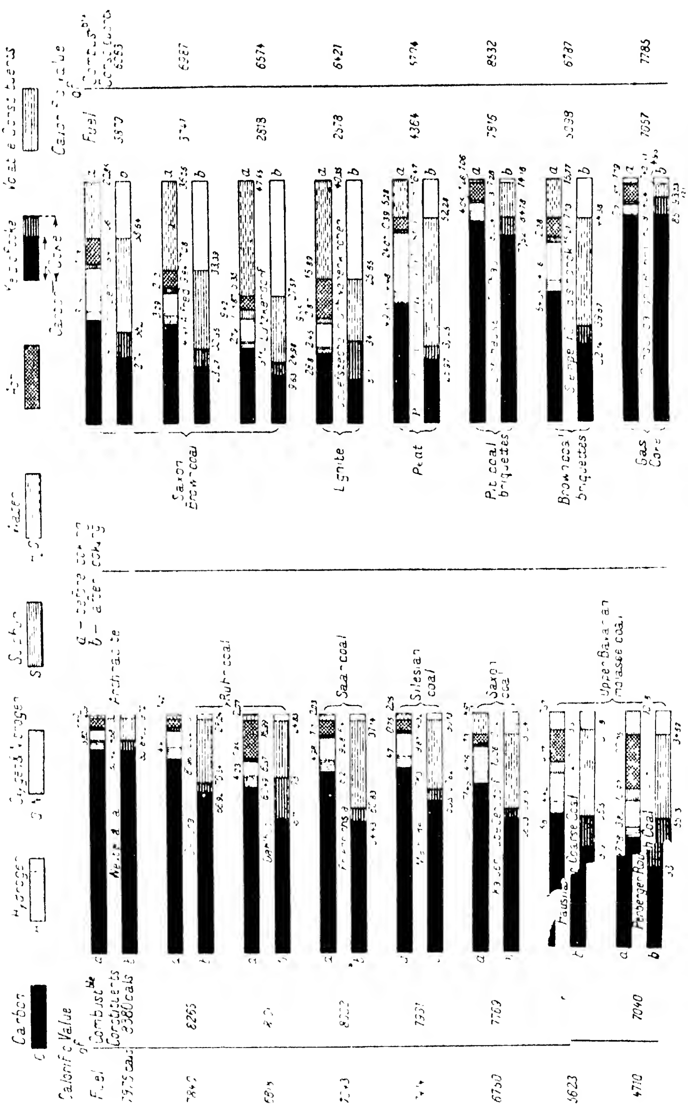


FIG. 111.—Graphic representation of the composition and calorific value of various fuels according to G. Baum Glückauf, 1906, No. 31

Fig. 111 is an accurate diagrammatic representation of the given numerical values, and shows quite clearly the position which medium-

quality German brown coal briquettes occupy in comparison with the various kinds of coal, lignite, and peat, as well as with coal briquettes and gas coke, as regards chemical composition, yield of coke, content of volatile constituents both before and after coking, and also with reference to the calorific value. As regards calorific value, the ratio of average brown-coal briquettes to coal is in general about 2 : 3, and if good briquettes are compared with poor coals the ratio is about 3 : 4.

F. EVAPORATIVE POWER.

The following evaporative powers have been determined by H. Langbein for various kinds of Central German briquettes described above at the instigation of the "Dampfkesselrevisionsvereins of Saxony."[1]

Origin.	Calorific Value determined calorimetrically.	1 kg. Crude Coal converts Water at 0° into Steam at 100° C.	
		Theoretically.	At 65 per cent. Efficiency.
	Cals. per kg.		
Bockwitz (industrial briquette)	1701	7·38	4·80
Meuselwitz	1929	7·73	5·02
Rositz	1900	7·69	5·00
,,	1829	7·57	4·92
Mölbis	1734	7·13	4·83

From 1 kg. Lauchhammer briquettes[2] (calorific value 1960 cals.) an average of 5·25 kg. normal steam (at 100° C. from water at 0° C.) were obtained during an 8-hour test at the Dresden Technical High School. The grate charge was on the average 112·2 kg. of briquettes per square metre of grate surface per hour, while 14·52 kg. water was evaporated per square metre of grate surface per hour. In the district of the Rhenish brown-coal industry recent evaporative tests undertaken by the Coblenz Boiler Inspection Co. on internally fired horizontal grates (polygonal) gave actual evaporations of 5·51 and 5·53 kg. corresponding to efficiencies of 70·0 and 70·4 per cent. Tests made by Engineer Oellereich on a Roux boiler, fired with briquettes, gave 6 kg., corresponding to an efficiency of 80 per cent.

According to these and other experiences, it can be concluded that 1 kg. of brown coal briquettes can convert—

[1] Polster's *Kalender für Kohleninteressenten*, 1904, p. 105.
[2] Glückauf, Essen, 1903, No. 35.

With ordinary firing arrangements, about 4·8 to 5 kg.
With firing arrangements specially adapted to their peculiarities, however, about 5·3 to 6 kg.
} Water at 0° C. into steam at 100° C.

under efficiencies corresponding to 65 and 70 to 80 per cent. respectively.

Comparing Bohemian brown coals with coals under the ordinary conditions of firing, the relationships obtained are somewhat similar to those obtained for the calorific values (see p. 303).

Since briquettes from certain of the best brands of Bohemian brown coals are more or less superior to good coals as regards calorific value and evaporative power, they are able to compete successfully with coals in comparatively wide circles principally because briquette firing provides considerable economies in fuel costs, which are still further increased in favour of brown-coal briquettes according to the distances and freightage costs. On this point the following example only need be given:[1]

The Aktiengesellschaft Lauchhammer of Lauchhammer, N.L., carries on an open brown-coal working with a briquette factory in addition to the well-known iron-works. A large proportion of the briquettes are used in the company's own works, the Riesa iron-works and the Groditz tube foundry. They are charged at the market price, and in this way quite considerable economies in fuel costs are shown at both works compared with the earlier use of Bohemian brown coals. At Riesa 1000 kg. superheated steam were obtained from Bohemian generator brown coal at a cost of 2·48 marks; with briquettes, however, the same amount of steam was obtained for 1·99 marks. Consequently, a saving of about 20 per cent. has been effected in the fuel costs by the application of briquettes. At Groditz the fuel costs per hour with the same heating plant and production was 9·04 marks, using Bohemian brown coals, but was only 4·40 marks when briquettes were applied, so that a saving of even 50·9 per cent. was effected at these works.

G. BEHAVIOUR ON BURNING.

Brown-coal briquettes ignite comparatively easily, naturally most rapidly at the corners and edges and possibly at the rough, fractured surfaces. Ignition gradually spreads over the whole surface, and in time penetrates to the core of each individual briquette. The evolution of volatile constituents and combustible gases proceeds gradually during the whole of the process of burning.

[1] "Die Braunkohlenbrikettfabrik der Aktiengesellschaft Lauchhammer," Glückauf, Essen, 1903, No. 35.

With equal size, uniform shape, density and homogeneity of structure and regularity of charging the briquettes develop the same gases at the same time and permit a regular distribution of the air and an almost uniform combustion. This favourable behaviour, as well as the complete absence, or at most the formation of only inconsiderable quantities of clinker, the low grate resistance and small air requirements because of the high oxygen content of the briquettes, renders it possible to fire and heat with only a slight excess of air, to regulate the necessary supply of air in accordance with the amount of gas evolved, thus leading to so complete a combustion (to carbon dioxide and steam) that none at all or only quite a small amount of soot or smoke is produced.

In the evaporation tests carried out at the Dresden Technical High School and described above (p. 303) smoke observations were also made and combined in the diagram given in fig. 112. It is obvious from this

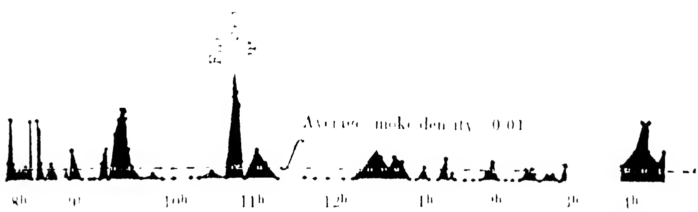


FIG. 112.—Diagram of the smoke observations during the firing of Lauchhammer briquettes in certain evaporation tests.

diagram that on burning Lauchhammer briquettes the development of smoke is cut down to a degree which would be very difficult to attain with other coals.

This favourable behaviour gives the brown-coal briquettes an important advantage over other forms of fuel and renders them eminently suitable for domestic fuels and for application to industries in large towns, in which the development of soot and smoke constitutes an intolerable nuisance. A comparison made from this point of view between towns in which the application of briquettes preponderates, such as Berlin, Magdeburg, etc., and those in which pit coals or Bohemian brown coals are mainly used, such as Hamburg and Dresden, is distinctly in favour of the former with regard to appearance.

For the heating of rooms, brown-coal briquettes and especially the large domestic blocks, if they are used in stoves of suitable construction and in a simple manner corresponding to their nature[1] retain their form

[1] For further information on this point see Section XII.

almost to the end of the combustion and provide a prolonged uniform glow and a high utilisation of the heating power. At the same time the stoves require but very little attention; stirring and poking is unnecessary and even detrimental, since the briquettes fall to pieces and burn much more rapidly; and are highly economical if never overheated.

In boiler firing and other uses for commercial or industrial purposes the long-flaming properties of the briquettes effect a uniform distribution of the heat, and consequently a great consideration to the boiler plates.

Residues of Combustion.—In the application for domestic purposes only a fine loose ash without any clinker is left behind. After complete combustion the ash is reddish yellow, due to a small content of iron; a dark colour indicates that it still contains unburned particles of coal. If good burning briquettes are left completely at rest so that they are not moved in any way, the constituents of the ash and the residual particles of coal, as already remarked, because of the gases developed during combustion, remain in a porous, semi-loose structure in such a manner that, apart from a certain diminution of mass, they retain the original form almost to the end. The stove ashes are very easily removed.

In industrial firing plants, where a much more rapid combustion with the development of a correspondingly greater amount of heat takes place, a slight formation of clinker can occur under certain circumstances in addition to the formation of ash. The clinker rests lightly in quite thin layers on the grate and can be loosened when required by means of a sharp-edged poker, then broken up and removed. It is quite sufficient if the grate is cleaned of clinker about three times during a twelve-hour run.[1]

Further information on the multifarious applications of domestic and industrial briquettes will be found below in Section XII.

[1] "Feuerungen mit Braunkohlenbriquettes," *Z. Braunkohle*, 1903, No. 5, pp. 61–62.

SECTION III.

THE MINING AND SUPPLY OF CRUDE BROWN COALS THEIR DRESSING (WET OPERATIONS), TOGETHER WITH THE DESPATCH AND ACCUMULATION OF THE BRIQUETTING COALS AND HEATING COALS.

A. THE MINING AND SUPPLY OF CRUDE BROWN COALS

The crude brown coals supplied to briquette factories may be obtained from open workings or quarries or from deep workings by mining operations. In open working it is first necessary to remove the upper soil (earth, sand, gravel, loam, rock, clay, and the like) covering the layer of brown coal.

By using dredgers for quarrying, and removing the material by means of locomotives and large tip waggons, the open working can be carried on with advantage when the proportion of earthy matter to coal does not exceed 2 : 1. Under special circumstances the proportion may be a little greater, but generally speaking open working becomes too costly when this ratio is exceeded, and deep working becomes essential.

Since a large proportion of the existing German brown coal beds lie so close to the surface that this limiting proportion is not exceeded, there are still a large number of open workings in operation. In many important brown coal districts, viz. on the left of the Rhine between Cologne and Bonn, at Horrem and in the Senftenberg district of Lower Lausitz, open workings are to be found almost exclusively. It might indeed be said that an overwhelming proportion of the German lignite briquettes made at the present time are produced from quarried coals. In briquetting it is of great importance that the coals obtained from open or deep workings should be subjected to a natural dehydration on drying grounds. These should be situated on open land at no great

distance from the position of the stratum or main exit galleries of the deep workings and the coal allowed to lie there until the water which has filtered into it from the upper soil has drained away in the water channels provided and a portion of its hygroscopic moisture has been lost by evaporation. In many districts the time necessary for this is about a year, after which the brown coal can be removed. The removal of water in this manner subsequently effects considerable economies in the briquette factory by shortening the costly process of drying.

If the natural dehydration is hindered by the presence of an impervious layer of clay, as is the case in several Lower Rhenish workings, the process is assisted by boring numerous vertical holes right through the clay bank of the drying ground.

Crude coal obtained from open workings is much more variable as regards water content than is the coal obtained from deep workings, since it is much more subject to the action of the weather. During summer months considerable drying takes place owing to the action of the sun's rays on the walls of the working, especially during long periods of drought and hot weather; while during heavy and continuous rains the material may even become soaked with water. Great cold can obviously bring about the freezing of coal in open workings, a factor which may be of considerable importance in the preparation by wet methods.

On the other hand, the getting of coal in open workings as compared with deep workings provides the very great advantage of considerably lower working and conveying costs, principally because of an almost trebled output per miner. For further information on this point see Section XI below. The following are a few examples of the conditions of the strata, the hewing and delivery of brown coals from open workings in Rhineland, Province of Saxony, and the Lower Lausitz, briefly described and illustrated by photographs.

Fig. 113 is a vertical view of the enormous brown-coal bed at the left of the Rhine at the so-called "Ville," between Cologne and Bonn, and shows the operation by means of open workings with special regard to the Rodder pit at Bruhl. Here the covering of soil, which is only about 5 to 8 metres thick (principally gravel and sand), is dug out by hand and removed in tip-waggons by a locomotive in order to be tipped in a worked-out portion of the seam. The coal stratum thus exposed—about 40 metres thick—is practically uniform throughout, exists in dense layers, and is therefore of great strength. There is very little woody matter. We see that the coal is hewn from the steep coal walls at the

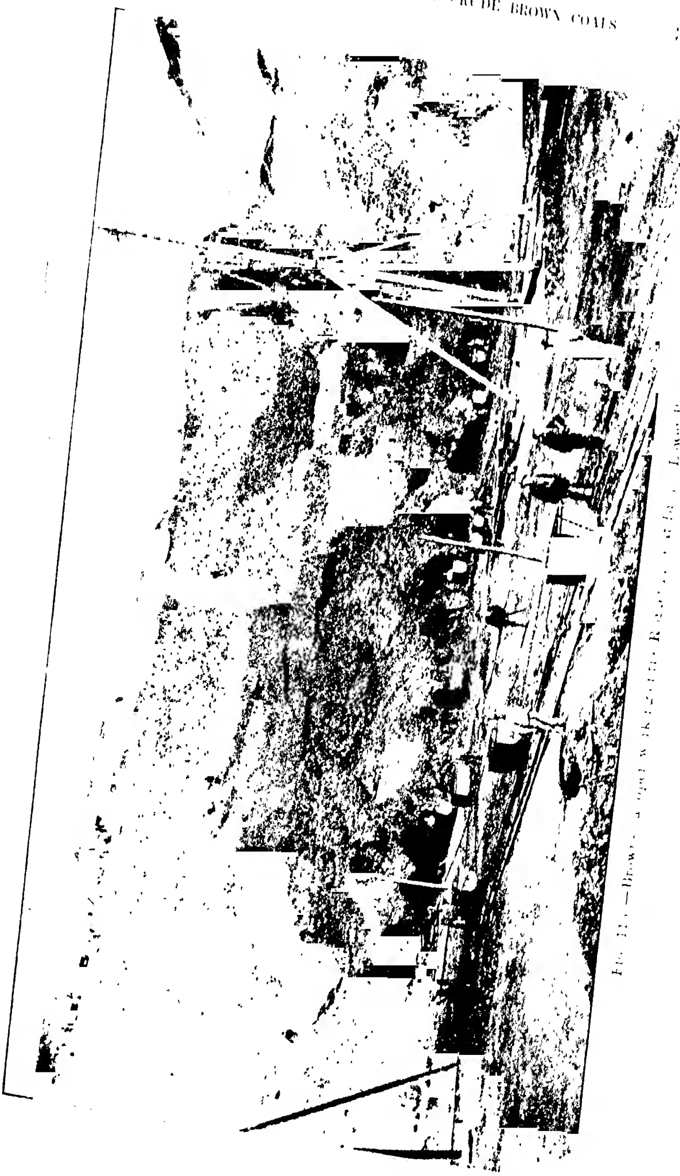


Fig. [illegible].—Brown [illegible] R[illegible] L[illegible]

back and the funnel shaped walls of the so called "excavation slides" and allowed to roll into the mine waggons placed below. Further, the full waggons are led from the front openings of the narrow base of the working towards the funnel necks (not visible in the picture) or cylindrical openings of the various excavation slides and delivered to the starting point of the chain conveyor, which can be seen at the left.

Here the full waggons proceed one after the other to the right track below the corresponding line of the chain conveyor running on horizontal end pulleys, while the empty waggons are drawn up the left (front) track of the chain. High standards with arc lamps serve for the electric illumination of the working during darkness.

The chain conveyor transports the full waggons from the workings to a rising stretch of track only partly visible and running along the coal wall at the right to the wet preparation ground of the neighbouring briquette factory, whose chimney towers above the working in the background of the picture.

Fig. 114, open brown coal working of the Hedwig mine at Wildschütz Akt. Ges. Naumburg, gives a picture of the typical deposit of the Saxony-Thuringia basin as well as a very regular mode of operation. The 18 to 20 metres stratum which exists here is distinctly laminated in the characteristic manner of the local deposits, especially in the upper portions, where a number of narrow, light yellowish-brown layers alternate with thicker and more or less dark coloured layers. The upper layers and especially the light coloured ones are generally characterised by a high tar content, but are only little or not at all adapted to briquetting and are much more adapted, particularly those very rich in tar, to working up in distillation plants (Schwelkohle). The remainder of the stratum, however, yields a very good briquetting coal. Woody or bristy residues from the trunks of trees and the like are only seldom met with.

The covering of soil, which is about 12 to 15 metres in thickness, is mainly removed by dredging close to the situation of the factory. The wall of coal to be removed is divided into sections of equal breadth and depth called "workings," each of which is intercepted in the middle by a cross gallery from the bottom of the working. In this way the seams are operated from above downwards. From the walls of individual slides enlarged to wedge shape the coal, as will be seen, is hewn away in strips, taken into the cars, pushed into the cross galleries, and conveyed to the main track running along the worked-out side. The lower remaining sectional parts from the slide opera-

Fig. [illegible]

tions can be obtained with picks spades and shovels with correspondingly lower output and higher costs.

During the hewing of the stratum care must always be taken that those layers which contain coal suitable for distillation are obtained and kept separate as far as possible and that these waggons are distinguished by special pegs or in some other way.

Fig. 115 shows as a typical example of the brown coal deposit and method of working in the Lower Lausitz, a section of the open working of the Eva mine owned by the Ilse Bergbau Akt.-Ges. Grube Ilse, N.L. The so-called upper stratum which was formerly over 15 and is now only 10 to 12 metres in thickness contains no layers of distillation coal but is however very rich in troublesome woody matter (lignite) which can be seen clearly in the picture.

In the middle section of the coal seam, almost in the centre of the stratum, is to be seen an upright massive stump of a tree (bog cypress) which has been uncovered. Such stumps are to be found in number during the working of the seam, especially in the horizontal position, where they are usually met with of considerable girth and lying close together, a proof of the autochthon origin of this deposit from a swamp forest on this spot. In addition to the woody matter in the vertical tree stumps other remains of plants more or less well preserved occur in a horizontal situation often forming shaped layers.

During the working the horizontal cubical, usually strong stumps, and other similar large portions of stumps of a strong nature are left standing unhewn. They are then carried to collective heaps in the bottom of the working and are given up to the workers gratis as fuel wood. The small pieces of wood hewn off are, however carried with the coal the soft coally particles can after suitable crushing, be briquetted while the heavier pieces are passed to the boiler-house. The picture shows three cross sections each about 5 metres in breadth ("workings") of a coal seam in different stages of hewing. On the right we see one of the cleft slides which is general in the Lausitz so called after the cleft which is hewn out of the front wall of a section, and which, together with the semi funnel-shaped coal surfaces around it serves as a slide for the coal obtained by the miner. The mine car to be filled stands in a niche below. A plank suspended in front of the cleft prevents the sliding coal from shooting past the waggon. The middle section is already hewn away for the most part, up to the residual coal at the back, obtained by means of pick-axes and shovels. The left section is only about half worked.

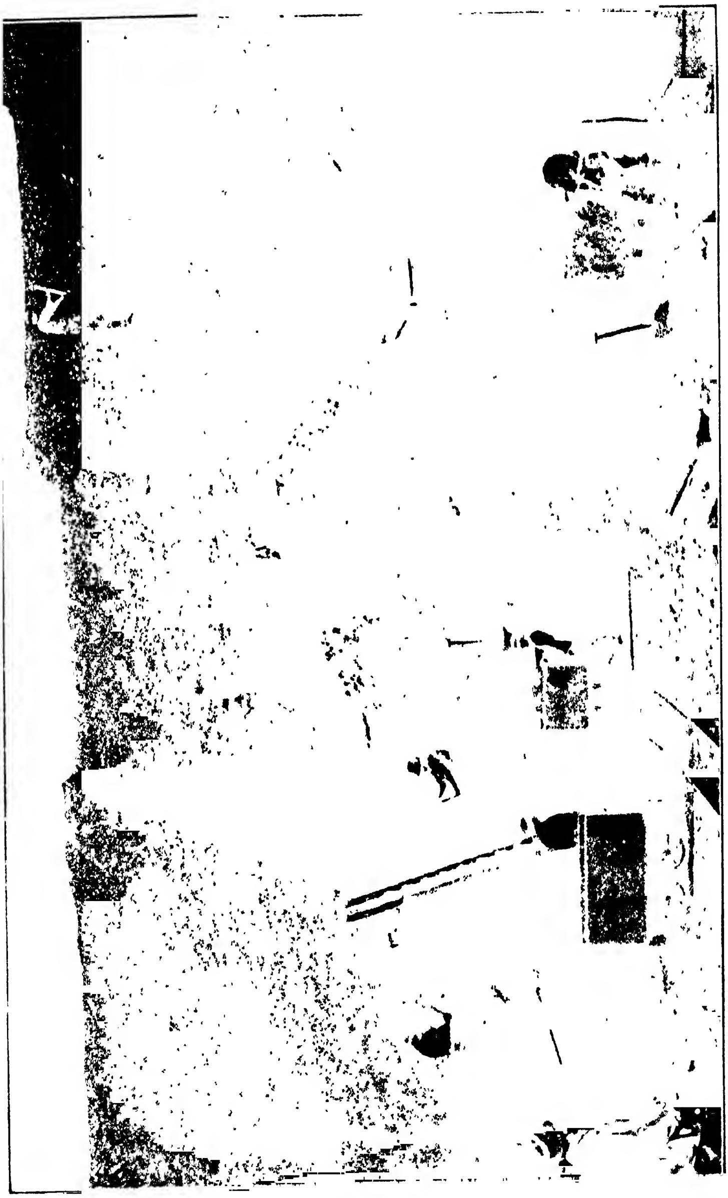


Fig. 115.—[illegible]

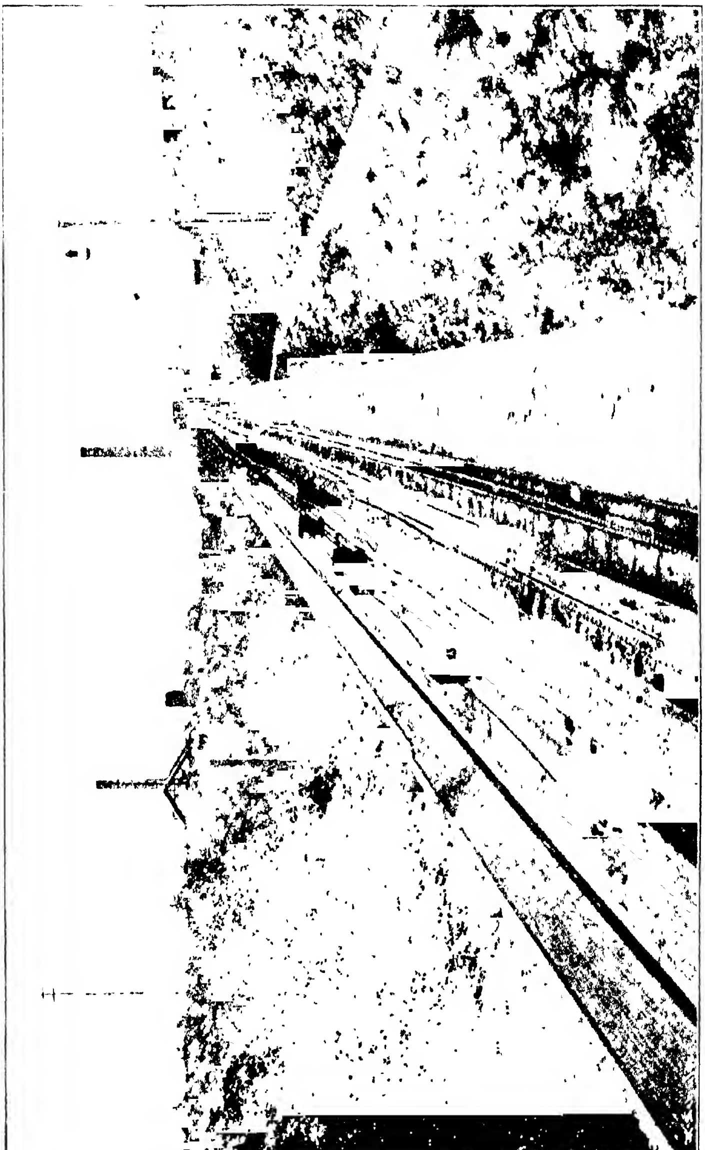
Each working is operated by one miner and two labourers, the latter taking the waggons to and from the chain conveyor. The output of a working usually amounts to 150 waggons of 6 hl.[1] per shift, the wages to 7·7 pfgs. per waggon and 12·5 pfgs. for the residual coal.

Fig. 116 illustrates the plant and operation of the inclined four-track double chain conveyor which leads from the neighbouring brown coal open workings of the Eva and Renate mines (already mentioned) (Ilse, Bergbau Akt. Ges., N.L.) to their briquette factories opposite. The factories are to be seen above on the left and right. Each is provided, independently of the other, with its own chain conveyor. However, a common rail track rising or falling 1 in 30 is utilised.

The inclined plane of the track is made below the surface of the land in a cutting with inclined sides in such a way that the breadth is sufficient not only for the four tracks with ample space between them but also for adequate footpaths on both sides of the whole track.

The inclined sides are planted with shrubs and protected at the foot by a lining wall. A masonry gutter runs along each lining wall to allow the rain and other water to flow away. At the top of the cutting the inclined track is continued on an iron trestle bridge until it divides in front of the factory yard. One branch continues straight to the wet preparation plant of the Renate briquette factory, while the other bends to the left and goes to the Eva briquette factory. The full waggons are drawn up the two inner tracks of the common plant and return empty down the outer tracks. The lines are laid with great care, and at equal short distances in the middle are equipped with rollers so as to protect the chains from rubbing on the bottom when the waggons are at great distances apart, an occurrence which is very apt to take place (see outer track on the right). Obviously the rollers must be well lubricated and kept in order. The chains of the inclined conveyor are of iron 24 mm. thick, those of the conveyor in the bottom of the working are 20 mm. in thickness. The iron conveyor cars hold 6 hl. of coal. For the purpose of drawing the waggons, there is riveted to the front end a thick piece of sheet metal of fork-shaped appearance (see also fig. 115) in which a link of a chain standing vertically is placed, while the following link lies at right angles to the first. This simple strong arrangement has proved to be the best, and is almost universally applied. The picture of the Rodder mine (fig. 113) shows a similar arrangement. When the waggons are pushed under the chain care must always be taken that the front

[1] hl. = hectolitre.



side provided with the carrier stands in the direction of motion of the chain.

The power stations, with the conveyor machinery driven electrically from the factory central station are not situated at the top as is usually the case, especially in the older plants but more conveniently at the foot of the inclined plane, so that the power acts first on the length of chain connected with the empty waggons and is then transmitted to the length drawing the full waggons. The necessary tension arrangements are placed above at the head of the inclined plane

At the left of the track the picture shows the electric leads to the driving station and the pumping machinery of the working and on the right the electric arc standards for electric illumination The output of the two chain conveyors usually amounts to 26 000 to 27 000 hl each, or even 30 000 hl of crude coal with forced working of which by far the greater proportion goes into the briquette factories and into the common boiler house

The whole rail and conveyor plant is standard It combines possibility of high output with great certainty in working, which is absolutely essential for the uninterrupted provision of large briquette factories in as uniform a manner as possible

Fig 117 shows the inclined double track chain conveyor between the working and the briquette factory of the Akt Ges Lauchhammer at Lauchhammer in the Lower Lausitz[1] In front in a cutting in the worked out seam the intermediate station to which the chain is led over tension rollers can be seen lying between the conveyor at the bottom of the working and the inclined plane

The inclined plane is about 800 metres long and rises with an average ratio of 1 27 to the upper story of the wet preparation shop of the briquette factory, where the chain driving station is situated If the chain is provided with waggons regularly, so that almost as many empty waggons (of 6 hl capacity) are coming down one side as there are full ones going up the other the electric driving motor must generate about 25 to 30 H P

A wire rope conveyor is illustrated in fig 118 The briquette and wet compressed block factory of the Naumburger Braunkohlen Akt - Ges, situated near Deuben station on the Zeitz Weiszenfels railway line, obtains its supply of crude coal (about 190 tons per hour) from the somewhat remotely situated mine by means of a wire-rope way built by the world-renowned firm of Adolf Bleichert & Co. of Leipsic

[1] Gluckauf, Essen, 1903, No. 35.

Gohlis. The aerial track runs at an obtuse angle round a large estate; the station at the angle is negotiated automatically or is attended to by a workman. In the front of the illustration is to be seen the last non-supporting structure with the conveyor wires situated on the left and right at its head, three electrical conductor wires fastened to the intermediate insulators, and the rollers attached to outriggers on both sides for the endless travelling wire which is led over horizontal pulleys at each end of the track and is kept

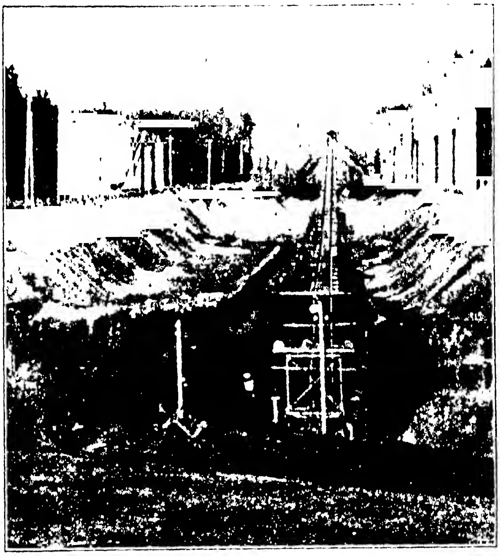
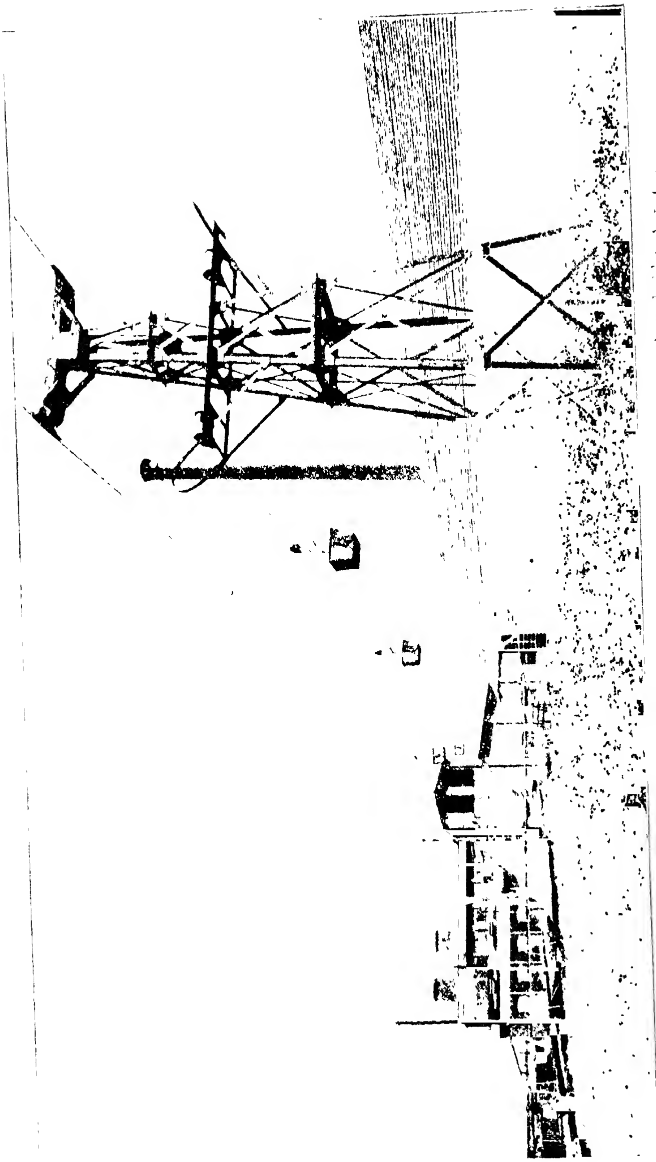


FIG. 117.—Ascending double track chain conveyor with ten ton appliance from the open working to the Lauchhammer Briquette factory.

steadily moving during the operation. Between the framework and the upper story of the briquette factory three hanging waggons (with deeply coned rollers in the hanger) are running along the travelling rope at the right and one along the left rope, full towards and empty away from the factory. They are drawn along by the travelling rope with the aid of the successful Bleichert clamp jaw coupling appliance, which allows the clamping of the travelling rope to be effected merely by the weight of the waggon and ensures a completely automatic and certain coupling and uncoupling. Uncoupling is effected at the unloading station simply by lifting the hanger with the container, for which purpose a pair of disc pulleys attached to the coupling is caused to run along a slightly ascending angular rail. By opening the



jaw clamps the waggon is set free of the travelling rope, and is then passed with its roller on to hanging rails which pass over the unloading stations (under certain circumstances with the aid of points), and at the bend is attached to the other travelling rope. In this way the emptied waggon is automatically clamped to the returning travelling rope.

The emptying of the waggons is mostly effected by knocking up a small fork-shaped trigger stop which is fastened like a hinge in the middle of the upper edge of one of the narrow sides, and in its horizontal position holds the box fast against the neighbouring leg of the hanger, but in the vertical position sets the box free so that it can easily be tipped over with the least push or by lifting a handle provided at the bottom, since the centre of gravity lies above the suspension pin.

In the small factory plant represented in fig. 118 the unloading station and the wet preparation plant are situated between the drying and press house on the left and the boiler house on the right. Behind the wire rope way the drying sheds for the wet compressed blocks are placed.

In general, wire rope ways are used to convey coal to briquette factories principally in places where by a possible erection of the factory at the mine itself or in its immediate neighbourhood the establishment of necessary railway connections is impracticable or appears to be uneconomical on account of difficulties with the land, great distance or the costs of transport being too high. Therefore it is preferable to erect the briquette factory at a suitable spot near to the existing railway line.

Automatic Carrying of the Conveyor Vessels to the Unloading Stations.—Now whether the raw coal from open or deep workings is conveyed into the wet preparation house in ordinary trucks by means of chain or rope or in hanging waggons by means of wire rope, it is generally advantageous, particularly in large installations, to allow the waggon after setting free of the motive appliance to run automatically from the conveyor track to the unloading station (circular tippler, supply grates or hoppers, charging hoppers, etc.).

With this object in view it is only necessary to cause the conveyor track to ascend up to the point where the waggon is set free of the moving appliance and then to fall along the branch track or hanging rails leading to the unloading station to such an extent that the individual waggons can attain their object comparatively quickly and without assistance. In this way a considerable economy in attendance is effected and the possibilities of accidents are diminished.

In order to allow of the correct distribution of the incoming waggons to the various unloading stations or supply tracks according to requirements or special instructions a certain number of points are required, as well as a suitably constructed point-lever appliance, which can be easily attended to by one man with safety.

The emptied waggons are pushed on to the corresponding return track and caused to return automatically with the aid of the appliance already described.

B. PREPARATION OF BROWN COALS FOR BRIQUETTING (WET PREPARATION).

I. General.

The crude brown coals delivered to the briquette factory are first subjected to a certain amount of dressing, such as coarse and fine pulverising combined with repeated sieving, to sort them on the one hand into briquetting coal of medium coarse and fine grain and meal, and on the other hand into boiler and heating coals which in addition to containing as much as possible of the coarse grains unsuitable for pressing, contain impure coals, pieces of coarse woody matter, as well as pieces of wood and other foreign materials which have been accidentally introduced into the coal.

These operations are combined together under the general common name "wet preparation" (Naszdienst) since they are carried out on the crude coals in their natural state containing all the pit moisture.

Many works with briquette factories also have a more or less considerable sale of rough coal. Then under circumstances quite excluding a fine crushing, the fine coal only is sieved off as briquetting material, and the coarse coal usually divided into several sorts of different sizes, which are shot into storage bins to be subsequently loaded into railway waggons or carts. Nevertheless, in order to be independent of the varying market for rough coal, which often fails altogether, the crushing appliances of the wet preparation cannot be dispensed with in order to apply the coarse coal, which at times cannot be sold, to briquetting in so far as it is not applied for firing boilers. In any case it is of distinct advantage to the works if they are in a position to increase the briquetting or sorting and loading of rough coal in accordance with the conditions of the market. Consequently only the real wet preparation, *i.e.* the sorting into briquetting and firing coals including their disposal and accumulation, will be dealt

with more closely in the following pages. With regard to the separation of rough coal the much discussed book *Die deutsche Braunkohlenindustrie*[1] is to be referred to. The sieving appliances mainly used in practice for this purpose up to the present (bar sieves, impact sieves, drum sieves, Karlik's pendulum sieves, Klonne's circular sieves, Schwidtal's double-bottom sieves, Kohle's shaking sieves) are described in detail.

The wet preparation is housed either in a part of the briquette factory building (in the centre or on the side situated next to the coal conveyor track) or in a special building which is connected with the drying plant and press house by a passage or some other similar way. In both cases this part of the factory is known as the "wet preparation house" or "moist house." For the internal equipment of the wet preparation house, the selection, number and arrangement of the various appliances, the following fundamental principles are generally aimed at:—

1. The whole wet preparation is to be adapted to the state of occurrence of the brown coal and the nature of the crude coal, particularly as regards its degree of hardness or softness.

2. Those particles of coal which already possess or have attained by corresponding preparation that degree of fineness and purity necessary for drying and pressing are to be sorted immediately from the remaining coal requiring further treatment and transferred at once to the arrangement (elevator, band conveyor) for passing on the briquetting coal, so that an unnecessary overloading of the rest of the wet preparation plant, in addition to an excessive crushing, will be prevented, since this would result in the production of an excess of dust later on.

At the same time the constituents of the heap unsuitable for or dangerous in briquetting are sorted out and removed as rapidly as possible; large pieces of lignite, however, should be broken as far as possible by suitable mechanical appliances, so that they can be conveniently charged on to the grate of the boiler along with the other boiler coals.

3. It is advisable to provide a special, correspondingly simple compound system of dressing appliances for the crude coals previously set apart for firing purposes and especially such portions of the stratum as are very woody, very wet, or contaminated with sand, clay

[1] See principal Part II, "The Mechanical Preparation of Lignite," by R. Cottler, especially Section I, "The Separation" (pp. 2–6).

pyrites, etc. This is very likely to occur in sloping or horizontal layers because of possible intermediate materials and disturbances.

4. The whole of the remaining rough heap from which therefore the briquetting coal must principally be obtained is in large plants, to be distributed to several neighbouring briquette coal systems of equal or similar construction and capacity. In this way excessively large crushing, sieving, and transport arrangements can be avoided and in addition the possibility of stopping one or other of the systems when the wet-preparation plant is not very busy, or there is a relapse in the sale of briquettes, interruptions in working, extensive repetition work, and so on, is also provided.

5. The appliances constituting one system are to be constructed, arranged together, and operated in such a way that the coal delivered above passes through or over them without assistance and that intermediate conveyors are avoided as far as possible, or if they are indispensable on special grounds the use of such auxiliary conveyors is limited to the absolutely necessary requirements.

6. The individual systems shall not take up more space than is essential. From this point of view it appears to be the most suitable to arrange the various appliances almost vertically below each other.

7. In addition to the previously mentioned requirements the distance of the apparatus and the various systems from each other is chosen so that every appliance is readily accessible, and can also be easily overlooked whilst in operation, so that stoppages or breakdowns can immediately be diagnosed and rectified, and damaged parts easily changed.

8. The whole of the supply and wet preparation appliances, as well as the arrangements for removing and collecting the briquetting and firing coals, are to be of such dimensions that they are capable of dealing with the whole coal requirements of the briquette factory for twenty-four hours, as well as the quantities of coal required for sale, in a single shift of ten to twelve hours. It is almost general practice only to run the wet-preparation and conveyor plant during the day shift, while the drying and press plant is kept running continually day and night up to Sundays and other holidays.

The following practical example of a complete wet-preparation installation will extend the discussion of the individual appliances of the wet preparation plant.

Wet-Preparation Plant in the Lauchhammer Akt.-Ges. Briquette Factory.—Fig. 119 shows a section through the wet-preparation house

of this installation erected by the Maschinenfabrik Buckau in the year 1901 and whose chain conveyor has already been described above (p. 316) and illustrated by fig. 117.

In front of the power station in the third story of the wet preparation house the chain sets free every newly arrived waggon which, if it does not contain boiler coal, runs into the circular tipper of one or other of the two similar wet preparation systems according to the position of the points, and is emptied into the charging hopper *a*. The coal is fed below by means of two small ribbed roll conveyors *b* revolving together to the crushing rolls *c* of 500 mm. diameter, revolving in opposite directions, and provided with projections which break up the pieces.

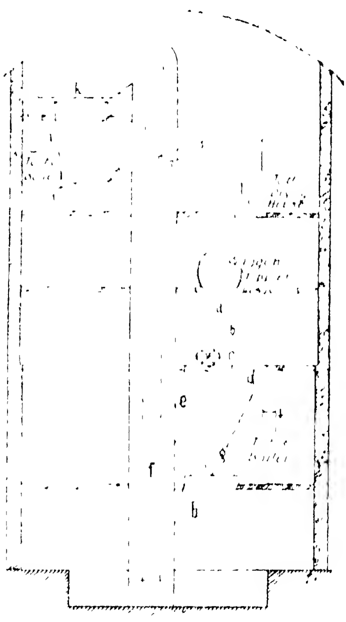


Fig. 119.—Wet preparation plant of the Lauchhammer Akt. Ge. Briquette Factory.

The outflow falls on the upper portion of the inclined shaking sieve *d*. All the fine coal below 10 mm. is sieved off here, and is led away by a slide *e* into the elevator *f*, while all the coarse material passes on to the lower part of the sieve. Its wider meshes allow the coarser grains of coal to pass through and to fall into the disintegrator *g* situated underneath. But the very large pieces, especially woody matter and the like, pass away over the side of the sieve on to the band conveyor *i*, which carries them to a small elevator (not visible in the picture). The latter shoots the boiler coal on to an upper band for further conveyance to the storage hoppers of the boiler plant. The material introduced into the disintegrator is further crushed, and the resulting briquetting coal allowed to shoot down the slide *h* into the elevator *f*. This, often called the "wet elevator," lifts the whole of the fine coal into the upper story and throws it on to the upper swinging sieve *k*, which sorts out some still existing woody particles or pieces of coal still too large and causes them to fall on the upper band

conveyor travelling to the boiler-house. The small coal, however, passes to the right again from the hopper below the sieve *k* on an ascending band, and through a hopper on to the horizontal band *l*, which finally delivers it to the coal cellar of the drying and press-house.

Between the two wet-preparation systems of this plant a third rough crushing roll with swinging sieve is arranged, in addition to which a roller crusher is installed for crushing the boiler fuel obtained from the open working. This wet-preparation plant has to deal with about 635 tons of rough coal per day apart from boiler coal. Driving is effected electrically by single motors. (For further information see Section IX. below.) More examples of complete wet-preparation installations are to be seen in fig. 126 and in the illustrations of complete briquette factories given later in Section X.

II. Details of Dressing by Wet Operations.

From the foregoing it is obvious that this must be divided into supply, crushing and sieving of the crude coals.

1. SUPPLY OF CRUDE COAL.

The supply is effected first by unloading the conveyor vessels delivering the crude brown coals into supply hoppers made of stout sheet iron and either left open, or closed just below the top edge by means of a gratework.

The former arrangement is to be met with especially in old and usually small plants, where the conveyor waggons are unloaded simply by hand lifting. For this purpose one of the front or side walls of the waggon body is arranged as a hinged valve, which can be loosened at the bottom by the removal of a bar, and, by lifting the waggon with the help of the hand-grips arranged in the middle of the opposite sides, opens outwards and allows the charge to roll out; or small mould or other tip-waggons are used, whose closed bodies are provided with a geared arrangement for tipping.

The grate is made of round iron, bar iron placed edgewise, or angle iron placed at 18 to 20 cm. from each other so as to keep back the large pieces of coal and lignite. Such pieces, although they can act as obstructions cannot be gripped by ordinary crushing rolls. The pieces of coal on the grate are broken up with a miner's wooden hammer or an iron pick-axe, while the woody matter retained is thrown aside, probably into a car, for occasional removal.

Tippers. In modern, and particularly the large plants unloading of the mine waggons is usually effected mechanically by means of a circular tipper into an open supply hopper (see fig. 121, in which, however, the mechanical drive is omitted). These tippers are not materially different from those used in pit coal preparation installations, which are of varied design and mechanically operated.[1] As soon as a full waggon is pushed into or allowed to run automatically into the tipper from an inclined track the mechanical drive is set in operation. The waggon is revolved once with the tipper whereby it is emptied, and then pushed or drawn on to the return track situated at the back. During full working it is possible to push out the empty waggons with the aid of the advancing full ones.

The capacity of a circular tipper amounts to about four to six mine waggons per minute, and consequently

With a waggon content of 6 hl. = 24 to 26 hl. of coal, and
" " " 7 " = 28 to 42 " per minute.

At large wet-preparation plants there are always several tippers in simultaneous use, one for every special wet preparation system.

Instead of circular tippers, top or front tippers can also be applied in which the mine waggons are pushed against a stop and automatically tip over at the front. Among other disadvantages, however, the emptied waggons have to be pulled back again on to the track, so that the devices are not suitable for large works.

Grids are not provided below the tippers for the retention and breaking up of large pieces. Crushing rolls must therefore be provided so that such pieces can be worked up.

In small- and medium-sized installations, a simple hand worked circular tipper or a head tipper usually suffices for emptying the boiler coals. In order to unload boiler coals into some part of the charging hopper of the boiler-house, it is most convenient to make use of a transportable circular or head tipper, provided, under certain circumstances, with an elongated platform, so that further movement of the tipper is only necessary at intervals.

The emptying of the overhead waggons of a wire rope way also takes place, after their passage on to the overhead rails, into an open supply hopper, either by hand as described above (p. 319) or automatically with the aid of a lever arrangement attached to the body of

[1] Illustrated and described in *Niederrhein. Westfal. Sammelwerk*, vol. ix., 1905, p. 42.

the waggon. During the journey the lever holds the clamping fork in the horizontal position, but at the unloading station contact with a rail moves the lever, which raises the fork so that the waggon is set free and overturns.

Conveyor or Feed Rolls.—The rough coal thrown into a supply or charging hopper falls or slides on to two feeding rollers arranged at the bottom, and which, in the general appliances slowly revolve side by side in the same direction, pick up the coal regularly with their projections, and push it forward to the crushing rolls situated in front. These rolls are either sheet-iron drums of about 480 mm length and 500 mm diameter, with strips of sheet- or angle-iron riveted on to them, or stout shafts provided with wings or ribs, etc.

At many plants the preliminary crushing rolls are preceded by a single feeding roller provided with wings, at other works two such rollers are situated centrally over the roll-crusher and revolve in opposite directions at a measured distance from each other.

The drive is usually effected from the roll-crusher by means of a chain wheel and a steel chain.

In the new ribbed crushing rolls of the Bernsdorfer Eisen- und Emaillierwerk a peculiar method of feeding by means of an upper and lower roller of unequal size is provided. At the same time the rolls act as crushers, as will be seen from the following description and the figs. 120 to 122.

II. CRUSHING.

The object of this important work has already been fully dealt with above (pp. 320–322). Pairs of rolls with ribs or teeth (breaking, ribbed, or toothed rolls) serve for the crushing of the large- or medium-sized pieces contained in the rough coal supplied, while smooth pairs of crushing rolls (smooth or fine rolls), centrifugal and beater mills are used for pulverising coarse grains.

1. Preliminary and Intermediate Breaking Machinery.

Bernsdorf Rolls with Projections (figs. 120 to 122). The Bernsdorfer Eisen- und Emaillierwerk at Bernsdorf in Upper Lausitz now builds roll-breakers with four rolls according to a system of its own for the preliminary pulverising of brown coals and similar materials. The construction which has proved to be the best in a series of tests is described in the following pages.

The rolls *a*, *b*, and *c* are feeding and breaking rolls revolving slowly

against each other which seize hold of the material shot into the supply hopper by means of the circular tipper (fig. 121), partly break and slowly push the coal against the principal pulverising roll *d* which revolves at a much quicker rate. The whole of the rolls are fitted with sharp steel projections in such a manner that the projections of one roll run in the grooves of the others, as can be seen in fig. 122, in which only the various series of projections and not the actual projections themselves are represented for the sake of simplicity.

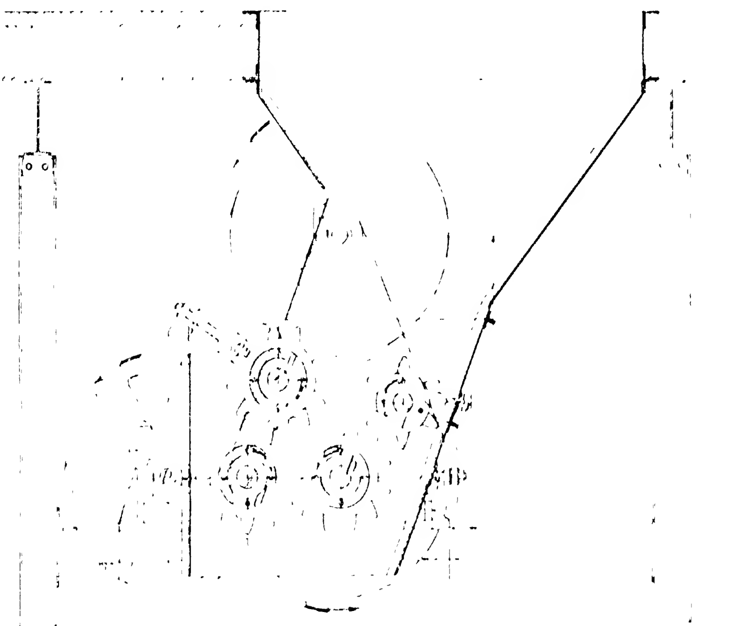


Fig. 120.—Roll crusher by the Bergedorfer Eisen- und Emaillierwerk. Section A B. Scale 1 : 30.

The feeding rolls *a* and *b* are housed in movable bearings fitted with spiral springs so that large strong pieces, especially lignite, which have not already been crushed like soft coal by the rolls *a* and *b*, can be gripped and pushed forward. By means of adjustments on the bearings the quantity and grain size of the broken material can be regulated, and in addition the possibility of facilitating the passage of pieces held up by occasional obstructions due to foreign matters or extraordinarily large and tough pieces of wooden roots can be provided for by placing the rolls further apart. In models Nos. 1 to 4 the breadth of the rolls amounts to 600, 700, 800 and 900 mm. respectively.

At an hourly output of 300 hl. the rolls *a*, *b*, and *c* make 8·2, and the roll *d* 71 revolutions per minute, at 1000 hl., 4 and 60 revolutions respectively.

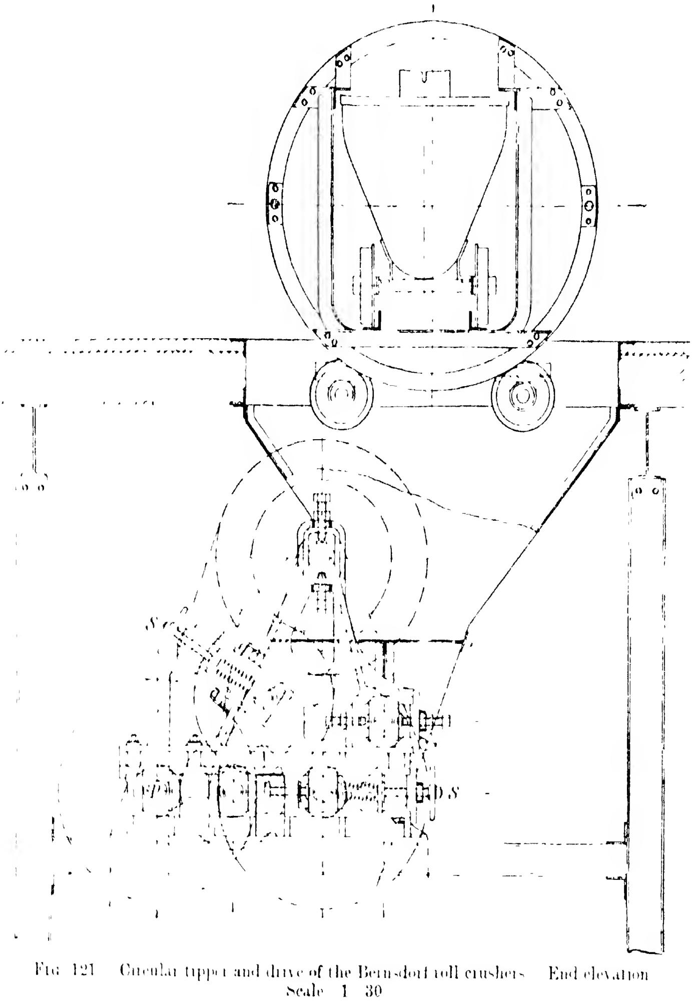


FIG. 121. Circular tipper and drive of the Bernsdorf roll crushers. End elevation. Scale 1 : 30.

The drive of the rapidly rotating main-crushing roll *d* is effected from the roll countershaft *e* by means of toothed gearing, while the feeding rollers are all driven by means of an Evart's steel chain in the manner depicted in fig. 121.

The feeding of the material supplied is effected quite uniformly

by the feeding rolls *a* and *b* independently of the size of the coal By means of the rotatory velocity of these rolls as well as the adjusting appliances, the output of such a roll can be regulated between comparatively wide limits according to requirements

The following figures are given for the average hourly outputs of the sizes Nos 1 to 4 350 to 600 600 to 800 800 to 1000 and 1000 to 1300 hl respectively According to the softness hardness, toughness, and size of the product the power required by No 2 at an hourly output of about 900 hl is 3 to 15 H P and up to 35 H P with very tough large pieces of roots etc

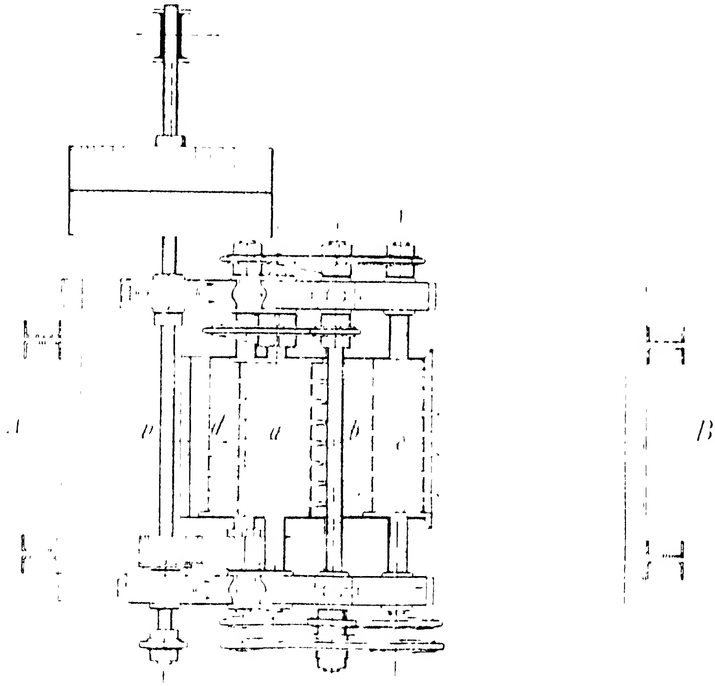


Fig. 122 Bernsdorf roll-crusher Plan Scale 1 30

The Bernsdorf roll-crusher affords the following advantages

1. Economy in power for the rejection of lignite and the breaking of larger pieces of coal on the grid of the hopper

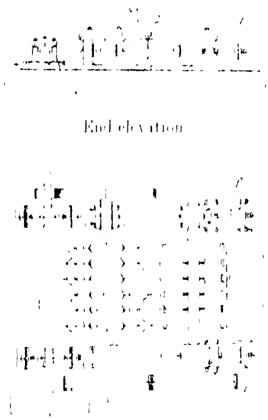
2 Rendering the lignite useful for boiler-firing

3 Perfectly uniform preparation for the following sieves, and so on.

4 High outputs great certainty in operation and simple attention

The Bernsdorf roll crusher can usually be introduced into the old wet preparation plant without considerable structural alterations.

Buckau Rolls with Projections (fig. 123). This much-applied roll-crusher, which has been made for a long time by the Maschinenfabrik Buckau (Akt. Ges.) at Magdeburg, is much simpler but much less suitable than the former for large and hard pieces of coal and woody matter. With regard to arrangement, equipment, and working the machine is fashioned on the lines of the two equal-sized rolls of the roll crusher for ore preparation. Each roll is built up of a number of wheel-shaped discs, which are keyed close together on the roll shaft and provided on the circumference with a number of projections of the shape of somewhat truncated square pyramids. The projections of the two rolls engage with each other, leaving a certain amount of play.



End elevation.

Plan.

Fig. 123.—Buckau rolls with projections.

The roll axles, together with a countershaft, are carried in bearings on a common horizontal frame, and the bearing of the axle on the right is rendered elastic by the stressed dashpot spring $f_1 f$, so that this roll can be displaced towards the left when strong large bodies (wood, iron, or stone) are introduced into the roll but cannot be broken by means of the projections. By this means, breakages of the projections or rolls are for the most part prevented. If, however, fractures do occur, or certain projections become very much worn, it is only necessary to change the discs concerned and not the complete roll. The drive is effected from a belt pulley by means of gear-wheels, which set the left roll in rotation and drive the roll on the right with the same velocity by means of a pair of angular toothed wheels made of cast steel.

The Buckau rolls generally have a diameter of 600 mm., with a length of 780 mm.; other designs go up to 800 mm. diameter and a corresponding length.

Rolls with Projections and alternating Star-shaped Discs.—At many briquette works, particularly those equipped by the Zeitzer Eisengiesserei und Maschinenbau Aktiengesellschaft, there are to be

found in place of the roll crushers previously described pairs of rolls with sharp projections consisting of ten five-point star-shaped discs 500 mm diameter, arranged on a square axle in such a way that the teeth and gaps of two neighbouring discs alternate. These rolls with projections are specially suitable for large pieces of soft coal.

Toothed Rolls. The toothed roll consists of a pair of rolls whose hard cast iron covers are provided, instead of with projections, with flattened elongated four-cornered teeth projecting in the direction of rotation. They are arranged in alternating rings and, like the above crushing rolls, are so fixed that when rotating against each the teeth of one roll engage with the corresponding spaces of the other. Rolls of this description are constructed by the Zeitzer Eisengiesserei mostly 800 mm long and 720 mm diameter, with teeth 30 mm high, in series of eight and more, not so much for the preliminary crushing of lumps of coal as for the intermediate pulverising of pieces of coal and lignite which have already been broken by an ordinary roll-crusher with projections, and more especially with coals of a hard and strong nature which are not well adapted to an immediate finished crushing by means of a smooth roll-crusher or a centrifugal mill. By the application of the Bernsdorf roll-crusher such a pair of toothed rolls can be very well dispensed with, particularly if the fine pulverising is effected in a centrifugal mill on the lines of the Perforce mill to be described below.

During working the stumpy teeth wear out fairly uniformly, but if the rolls work unsatisfactorily because of considerable wear and in spite of closer adjustment, the whole cover must be renewed.

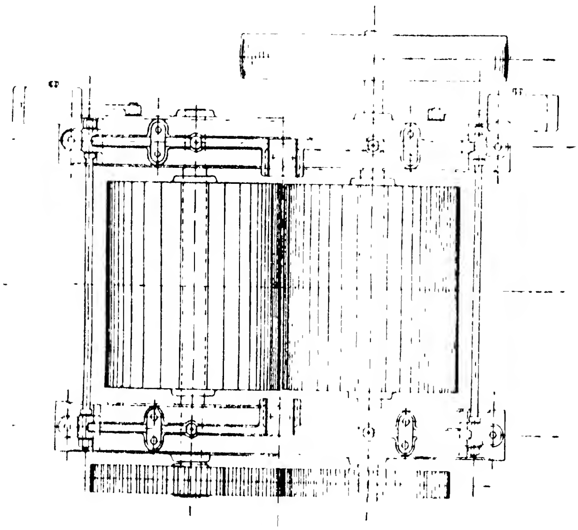
A piece of sheet iron with openings for the teeth can be fixed below the length of each roll to scrape away the adherent crushed coal. It is described below in connection with the smooth roll-crushers, and is illustrated in fig. 124.

2. Fine Pulverising Machinery.

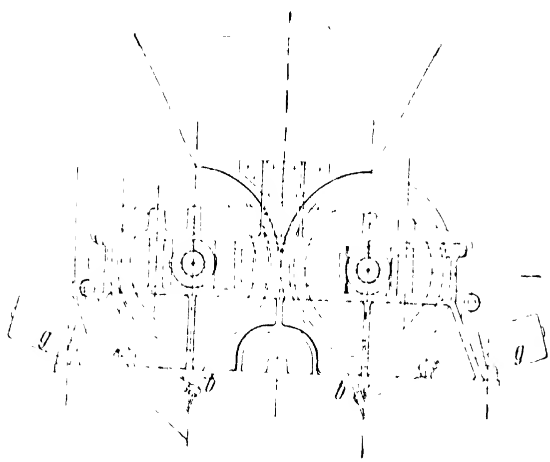
Smooth or Fine Roll-Crushers (fig. 124). The design differs from that of the previously described tooth roll-crushers only in the absence of teeth and the close adjustment of the smooth hard cast iron covers, whose distance apart amounts to about 10 to 14 mm, according to the nature of the coals, the length and diameter being approximately the same as the corresponding roll-crushers with projections. The pair of fine rolls of Buckau construction illustrated in fig. 123 is 900 mm long by 850 mm in diameter. Inclined pieces of sheet iron pressed

into position by the loaded levers g, are provided on both sides for scraping away the adherent coal.

The smooth roll is well adapted for bean-sized, specially hard coal;



Plan



Side view

FIG. 124.—Smooth roll-crusher. Scale 1 : 30.

but less so for particles of brown coal, which are often squashed out or exist in the form of splints and simply pass through without being gripped. It scarcely has any effect at all on very soft and wet

unctuous coals However, centrifugal mills have the advantage of simpler design over the smooth rolls, in addition to less necessity for repairs, and require considerably less power

According to various reports, the introduction of frozen coal (frost coal), obtained from open workings in winter into the fine crushing rolls is very likely to cause stoppages, on the other hand, however, it is claimed as an advantage of the fine crushing rolls that they are capable of working up frozen coals better than the centrifugal mills This discrepancy is probably due to the different natures of the coals and perhaps also to variations in the size and gaps of the fine rolls applied.

Centrifugal Mills.—The centrifugal mills built on the principle of the cam disintegrator have already been described in detail and illustrated by two diagrams (figs 17 and 18) in Part I of this book Since the centrifugal mills usually have to deal with considerable quantities in the wet preparation of brown coal, they are only used in very large sizes, corresponding to models No 6 or 7 of the table of the Maschinenbauanstalt Humboldt centrifugal mills given on p 66 In the size most frequently used the external circumference of the four concentric bar rings has a diameter of 1600 mm, and the whole mill has a diameter of 700 mm. It revolves at 200 to 260 revolutions per minute, and when consuming 30 to 50 H P has an output of 5000 to 7000 hl of coal per working day of ten hours

Centrifugal mills are generally well adapted for medium hard and soft lignites—although they deliver many pieces which are insufficiently crushed—but are not suitable for pulverising lignite splinters, which they scarcely crush at all

At the Renate briquette factory described above (p 314) each of the three centrifugal mills delivers per working day of ten hours about 150 hl waste, of which about half consists of large grains of coal and wood chips which will not pass through the final shaking sieve and are taken away to the boiler house This not inconsiderable waste has traversed the whole of the wet preparation plant, and represents an unnecessary encumbrance as well as a corresponding diminution in the briquette production [1]

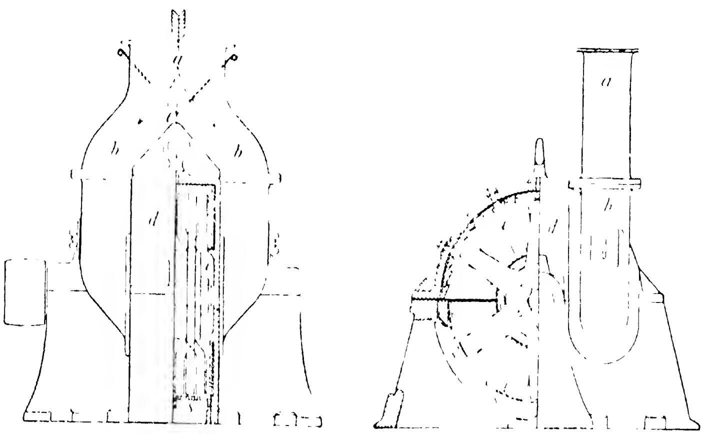
Elongated fibrous chips easily become entangled in the various bar drums revolving in opposite directions, and give rise to corresponding stoppages and interruptions of working. Similar results are effected by very wet unctuous coals, which readily cling to the bars, etc At many works the experiences with regard to the working up of frost

[1] *Die deutsche Braunkohlenindustrie*, 1907, section II, p 20

coals have been unfavourable, while at other places the centrifugal mills have proved quite satisfactory in this respect (see the remarks on the fine roll crushers).

Their great sensibility to foreign bodies such as pieces of iron, their high consumption of power, have already been dealt with on p. 65, where the advantage of giving an intimately mixed loose product is also mentioned. In the wet-dressing plant the drums of the centrifugal mills wear away somewhat rapidly, and must be renewed after 1 to 1½ years.

Hoffmann's Beater Mill (Perforce mill)[1] (fig. 125).—This mill was designed and built in 1904 by the firm of F. Hoffmann, Maschinen-



Front view and section. Cross-section and side view.

Fig. 125.—Hoffmann's beater mill—Perforce mill.

fabrik und Eisengieszerei of Finsterwalde, Lower Lausitz, for the Grube Ida I at Dobrilugk Ruckersdorf in order to increase the output of the wet-dressing plant from about 3000 hl. to 5000 hl. of raw coal per day, corresponding to the installation of another press, etc. The solution of the problem was a complete success, and the extra space required was obtained by abolishing the coarse sieve which now became superfluous.

To a certain degree the Perforce mill is a combination of the Excelsior and the cross beater mills, which are widely applied for the fine crushing of potash salts and other materials. In the constructional design represented in fig. 125 the coal is introduced into the delivery shaft *a* and distributed by *c* to the two tubes *b b* from which it runs

[1] B. Reinhardt in the *Zeit. Braunkohle*, 1906, iv., No. 5, p. 701.

into the intermediate grinding drum *a* from left and right in two approximately equal streams.

Pulverising is effected by steel beaters fastened on the shaft in the form of crosses, each consisting of four to six arms acting immediately on the material throwing it against the toothed steel plates *c* fixed on the side walls and the circumference, and grinding the coal until it is sufficiently fine to fall through the sieves on the periphery of the under side of the framework.

Originally the sieve was made of a sheet iron stamping, but since this wore out rapidly it has of late been constructed of triangular iron bars 10 mm. side placed 30 mm. apart, with a flat side uppermost.[1]

The coal, whether hard or soft, dry or moist, is completely pulverised by the Perforce mill. The working up of coal obtained from open workings during heavy rain offers no difficulties, only the dripping wet coals which have lain in pit water for a long time and the coals from the undrained portions of the stratum need be kept away from the mill, since the wet woody fibres easily become entangled in the sieve openings and cause stoppages. Woody matter and even green wood (from pit props and supports) leave the mill as chips usually of a sufficient degree of fineness; consequently stoppages of the tube driers by chips and heaping up of chips between the sheet metal stirrers of the table driers do not occur to the same degree as formerly. Even pieces of iron, such as nails, screws, and the like, are broken up by the mill without damage. The parts subjected to wear can be readily renewed.

The cast steel shaft of the mill revolves in long adjustable bearings, with white metal linings lubricated on the ring system and fixed close to the framework, so that it is protected against bending under the heaviest stresses. The certainty in operation appears to be very great. At the Grube Ida I, already mentioned, no repairs have been necessary even after two years' working.

A further advantage is that coal which is not too hard or woody can be delivered directly to the Perforce mill without preliminary crushing, and that after pulverising the coal can be taken directly to the elevator without once having to be passed over a sieve. Consequently only a single sieve (to sort the fine material from the supplied crude coal before crushing) is required for the whole wet preparation plant, and only one crushing machine (the Perforce mill) is required for working up the coarse material passing over the sieve, so that a very considerable simplification of the wet-preparation plant is obtained.

[1] *Die deutsche Braunkohlenindustrie*, 1907, p. 21.

The output and power consumption of the Perforce mills are approximately equal to those of the centrifugal mills of the sizes generally adopted (see p. 333).

III. SIEVING.

Plain sieves only, with vigorous shaking or jolting motion which keeps loose the particles likely to adhere and hinders stoppage of the sieve openings, are adapted to the sieving of wet, fibrous, earthy, or woody brown coals. Revolving-drum sieves soon become stopped up and ineffective. Consequently, flat sieves exclusively are applied in the wet preparation.

If the sieving of the crude coal (with or without one or several crushings) is only carried out with the object of obtaining briquetting and burning coals, simple shaking sieves, *i.e.* sieves with only one sieving surface, are employed. If, in addition one or several kinds of nuts for sale have to be sorted out, the oscillating sieves with several surfaces find suitable application as has already been described above (p. 321). In addition, a simple shaking sieve may be necessary for further dressing the briquetting coals according to requirements.

Shaking (Oscillating) Sieves.—The shaking or oscillating sieves usually employed are of long rectangular shape and are made of wire-netting or, still better, of sheet iron stampings 1 mm thick. Wire netting contains a larger number of sieve openings per unit of area than sheet iron sieves, but wears out much more rapidly by abrasion and rusting. At the top and both long sides the sieve is enclosed by a framework of wide boards, but is left open at the lower narrow side. Here it is suspended at both corners from a beam or girder by two iron bands, flattened wire ropes, or wooden planks provided with spring attachments. By means of a belt-driven, right-angle crankshaft attached to its head, the sieve is moved rapidly too and fro in the direction of its length, while two heavy compensating flywheels situated on either side of the crankshaft prevent the otherwise unavoidable shocks and adherence of the coal-layer, etc. The number of revolutions per minute amounts to 140 to 200 and occasionally more, the power consumed being 1 to 2 H.P.

By means of the shaking or vibratory motion of the sieve inclined at an angle of about 10° or 15°, the coal charged at the top is caused to move in jolts and bounds over the surface until it falls either through the meshes or from the open lower end of the sieve.

The breadth of the surface of the sieve depends upon the amount

of coal to be worked up and usually amounts to between 0.8 and 1.2 metres, generally 1 metre (*i.e.* equal to the breadth or length of the fine crushing rolls employed). The length of the sieving surface depends upon the coal supplied since a longer or shorter traverse is required to obtain the requisite classification with a definite mesh size, sieve inclination and speed of rotation according to the composition and nature of the coal. Further it depends on whether the sieve is made up of one sized mesh or of a number (up to three) of sections of different meshes.

In modern installations the upper shaking sieve receiving the crude coal of all sizes from coarse pieces down to fine meal is usually 4 to 4.5 metres long, while the second and occasional third sieves are from 3.5 to 4 metres long. In older plants shorter sieves are also met with, the shortest permissible length being 2 metres. Many machine factories (particularly Buckau) at the present time prefer on constructional grounds, shaking sieves of uniform length and breadth (*e.g.* 4 and 1 metres respectively) throughout.

Consequently the sieving surface in modern plants with a breadth of 1 metre amounts to 4 to 4.5 or 3.5 to 4 sq. metres, while in the older plants it is generally much less, even down as low as 2 sq. metres. The sieve openings are generally quadratic or nearly quadratic. The size of the mesh varies in sieves of two sections from a minimum of 10 × 10 or 10 × 12 mm to a maximum of 16 × 16 mm in the upper portion extending for two thirds the length of the sieve (average meshes are 12 × 12, 12 × 14, 14 × 14 up to 14 × 16 mm), while in the lower section the size is 80 × 80 or 90 × 90 and above. At the No. III briquette factory of the Grube Clara at Neu Welzow, Lower Lausitz, the first sieve is built up in three sections, the upper portion extending for approximately two thirds of the sieve surface (2000 mm long) has a mesh of 14 × 16 mm, while the lower third for a length of 500 or 400 mm long has a mesh of 40 × 40 and 80 × 80 mm in order to retain the charcoal better. The sieve is stamped, is 900 mm broad, and makes 180 strokes per minute.

C. THE REMOVAL AND COLLECTION OF THE BRIQUETTING COALS AND THE FIRING COALS.

The fine coals obtained during the wet preparation must be removed immediately, and conveyed to the coal store above the drying ovens of the drying and press-houses, the intermediate products must be carried to the subsequent crushing and sieving arrangements and

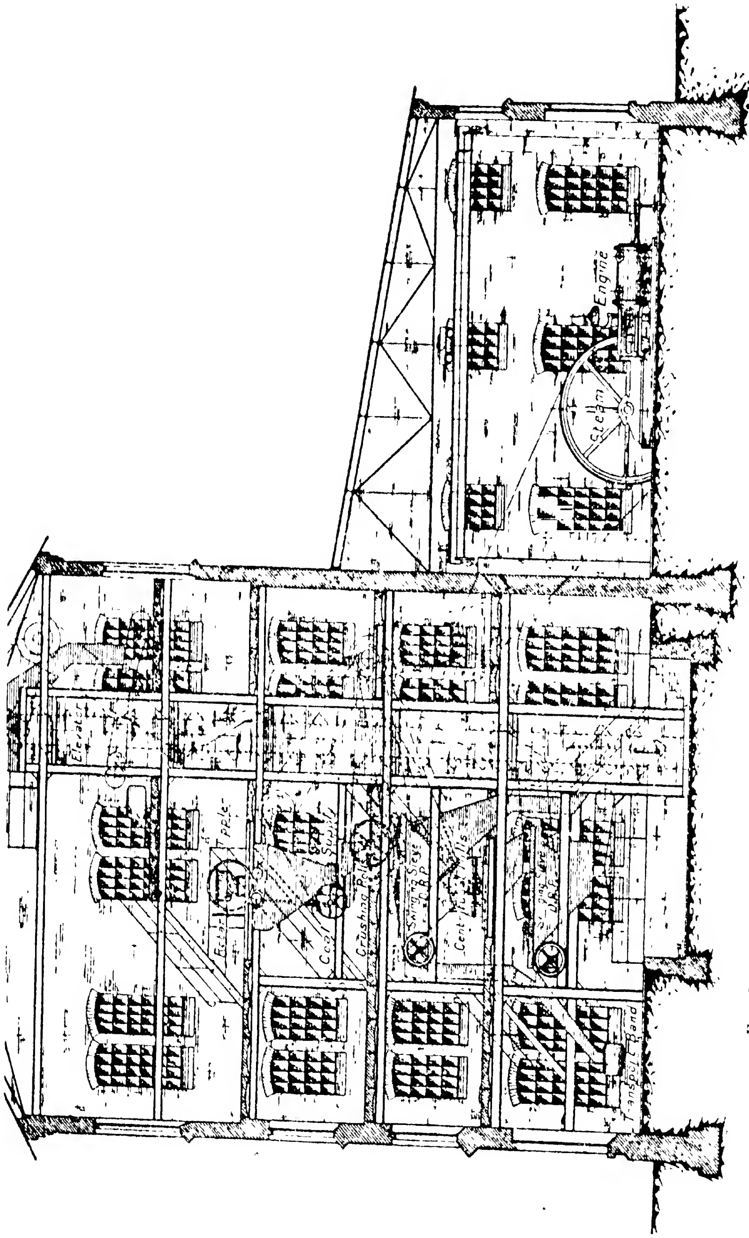


FIG. 126.—Wet-preparation plant with drive from a steam engine Maschinenbau Buckau scheme.

the ready sorted coarse and impure coals, woody matter, chips and so on have to be transported to the charging hoppers of the boiler house. For these purposes chutes or slides, elevators, and band conveyors are employed.

The chutes or slides are strong four sided funnel shaped hoppers of sheet iron, whose sides must fall as steeply as possible (at least 45 to 50°), so that the moist material charged in above can slide or roll down solely under its own weight without collecting and adhering to the walls.

Figs 120 and 126 show, among other things, the various chutes in their relation to the remainder of the wet preparation plant. The chutes for briquetting coal open into the corresponding elevator.

Elevators are almost universally applied for lifting up the briquetting coal. They are called "wet elevators" to distinguish them from those which have to deal with the dried coals later on (dry elevators).

A wet elevator is shown in each of figs 119 and 126 in the usual vertical position inside its masonry tower. The construction of these elevators differs from the elevators for pit coals described and illustrated on pp 54 to 55 in that the leading rails for the chain links are omitted because of the vertical position and direction of up and down motion. Further, the chain is made up of much smaller links, frequently it is an Evart's chain, composed of cast-steel hinged links which can readily be attached to one another, so that the chain can be made more elastic and allow the elevator to be driven at a higher speed.

Fig. 127. Portion of an Evart chain for elevators.

In fig. 127 a portion of an Evart hinged-link chain as made according to the design of G. F. Laeder, of Wurzen, Saxony, a specialist in transport installations is illustrated. Such chains are now often used.

Usually every fourth link is provided with side wings, to which a bucket can be fixed. The chain sections or the length of the individual links usually amounts to between 115 and 160 mm, according to special circumstances.

Double-link chains are often applied for large elevators with roomy buckets.

Instead of hinged-link chains, ordinary chains, either single or preferably in pairs, can be applied. Generally, however, their certainty in operation is much less, and they elongate sooner and to greater extent than the hinged-link chains.

Above and below the chains of either type run round a correspondingly designed chain wheel. The upper wheel or the two upper wheels (for a double chain) are mounted on a shaft carried on strong beams and fitted with a toothed wheel, which receives its drive by means of a gear wheel and a belt pulley from a transmission shaft or a special electric motor. The lower chain wheels with the shaft are best made adjustable by means of a spring adjustment, which is usually set into operation by means of a hand wheel and a screw spindle. The object is to keep the gradually stretching chain always taut.

The following are the principal dimensions of a vertical elevator with a capacity of 800 hl. briquetting coal per hour:—

Outside diameter of the chain wheels	825 mm.
" " upper pulley shaft	116 "
" " lower "	90 "
Number of revolutions of the upper pulley per minute	20 "
Distance between the two chains from centre to centre	405 "
" two buckets	405 "
" the lower and upper chain wheel shafts	24 m.
Clear distance between the narrow walls of the brick tower	750 mm.
Thickness of the narrow walls of the brick tower	260 "

Small vertical elevators for chips and the like, whose height seldom exceeds 8 to 10 metres, only require as a rule a wrought-iron building.

Inclined elevators may become necessary under special conditions of situation. Their construction is very similar to that illustrated in fig. 12 (p. 54). The elevator is housed inside a wrought-iron structure and supported on inclined rails, and consumes considerably more energy than a vertical elevator because of the frictional resistance set up.

Band Conveyors (Transport Bands, Belt Conveyors).—Iron band conveyors, such as have been described above on pp. 53 and 73 for pit coals and coal pitch mixtures, are practically never met with in lignite-briquette factories. For the usually much softer brown coals, bands of webbing material are preferred. At both ends of their path of travel they run over large iron rollers and are carried over intermediate upper and lower series of small carrying rollers, generally arranged at equal distances from each other. Fig. 128 shows, among other things, such a band conveyor with the rollers (*i* and *l*).

Up to the present Balata belts have proved to be the best for moist

brown coals. They are prepared from a strong webbing material covered with balata, and are extraordinarily strong. For dry hot material such as is obtained in the drying operations, however, they are not at all suitable, since they rapidly become brittle and are soon put out of action.

The width of the belt for conveying large quantities of briquetting coal amounts to 700 or 800 mm., but for small quantities, such as boiler coals or chips, 500 to 600 mm. is sufficient.

The length of the belt varies largely, according to the size and disposition of the plant, according to the position of the wet operation shop with regard to the drying and press house on the one hand and the boiler-house on the other. If the three shops form a long continuous line, with the wet-preparation house in the centre, a conveying length of about 70 to 90 metres with about double the length of belt exists in a very large plant with twelve presses and the corresponding number of steam boilers.

One of the two main rollers is provided with a spur wheel to be used as a driving roll, while the other is provided with an adjustment so that it can be displaced in a horizontal direction. The adjustment can, for example, consist of a horizontal bar fastened to the end of the roll with a piece of wire rope led over a roller and loaded with a heavy weight.

The small carrying rollers are placed in iron bearings provided with dust-proof lubricating arrangements at distances up to 12 metres if a taut belt is used. The belt conveyors can be led in horizontal or slightly rising or falling (up to about 20° or 25°) directions with moist brown coals or pieces of lignite without the material sliding off. Further, they permit of a fairly high velocity (1 metre per sec. and above), and are therefore capable of a high output if they are very wide. In order to utilise the width of the belt as much as possible and at the same time to prevent continuous waste, the material is delivered in such a way that it forms a continuous flat heap moving forward with the belt. The heap is highest in the centre and inclined towards the two edges, which it does not quite reach. For this purpose there is required at each point of delivery, just above the belt and at a certain distance from each edge, a long narrow well-planed plank or a corresponding piece of sheet iron fixed at the upper edge and rigidly attached to a bar, preferably in such a way that the boards at the edges converge in the direction of motion of the belt. The material thrown on to the belt from the spout of an elevator or from a travelling

belt is limited at both sides and held together by the boards or pieces of sheet iron, so that it remains completely on the belt during the travel in spite of the natural inclination towards the edges during motion. Having attained its object, the material is thrown off the belt in the direction of its motion or taken off at the side by means of a scraping arrangement.

At the end of the length of the band the removal of the material is effected by the fall and return of the band over the tension roll. The material falls either on to the floor of the coal store, into the storage bins of the boiler-house, or on to a second or third band conveyor, which is usually arranged at an angle below the first so that the material can be carried further in a different direction, as in the example given previously (fig. 119). A scraper is necessary in every case when the coal is required to be taken from the band before arrival at the end, so as to distribute it over the whole length of the coal store and to slide it direct to the drying ovens placed below, through openings in the floor, as regularly as possible. The same remarks apply to the various storage bins for boiler coals. The ordinary scrapers are for the most part similar to those used for pit coal and hard pitch on iron band conveyors (see p. 69 *et seq.*, and figs. 21, 24, and 25), namely, long pieces of wood or metal plates, which are arranged approximately vertical and at an angle across the belt at each point of removal. They are attached to small bars or rails so as to be adjustable and removable, and each forms a dam against the oncoming fresh coal.

This first heaps up, but in consequence of the inclined position of the scraper it is gradually pushed to the side by the continued motion of the band and pushed along the plank or sheet iron until it finally falls over the edge of the band. If the scraper stands close to the belt all the coal is scraped off; if it is placed a certain distance from the belt only the upper layer of the coal is taken away, while the lower layer remains and is carried away underneath the scraper. The coal can also be removed in the complete layer, but only from a certain portion of the width of the belt, and the remaining material is allowed to travel further. In order to deflect the coal to the other side of the belt it is only necessary to reverse the scraper accordingly.

In place of this simple arrangement, practice has recently turned to the use of double scrapers over wide belts. They consist of two short equal lengths of board or sheet iron standing inclined in opposite directions in the middle of the band, and forming together a wedge-

shaped dam which divides the oncoming coal and causes it to fall in equal quantities at the left and right. An arrangement of this description, which has been constructed by the Zeitzer Eisengieszerei for No. III. briquette factory of the Clara mine at Neu-Welzow, Lower Lausitz, is very suitable for the purpose. The two scrapers are shovels provided with handles at the top, and at the back with two pairs of angle-irons standing vertically, each of which leaves free a T shaped intermediate space as a guide for the introduction from above in a horizontal position of screw bolts with head plates which can be displaced vertically.

The other ends of the bolts pass through corresponding holes in a sharp-edged horizontal flat rail bent roughly to a right angle and arranged over the middle of the belt and are screwed up tight by means of wing nuts. In this way the scraping shovels are also fastened to the flat rail one to the right and the other to the left leg so that they come together in a wedge shape over the middle of the belt and can be fixed close to the belt or more or less removed from it according to requirements. The flat rail is fastened at the two bent ends to vertical stands made of angle iron.

With a breadth of belt of 700 mm. the length of each scraper shovel is 500 mm. and the height 350 mm.

The band conveyor with its rollers and scraping appliances must be as accessible as possible from both sides of its whole length, and particularly in the region of the coal store. A suitable arrangement for this purpose is an iron bridge on each side of the belt. This consists of flat rails connected with each other at equal distances of about 1½ to 2 cm. and laid on light cross-beams parallel to the band conveyor. The free outside edge of the footbridge is protected by means of a simple railing.

The *coal store* serves for the accumulation of the briquetting coal transferred from the wet operations, and usually forms, since the several drying appliances are almost in every case arranged in one story below, a more or less lengthy brick room, which is of such dimensions that it can supply sufficient stores of coal for twenty-four hours' working. A suitable floor consists of a flat upper arch, which is supported on iron girders and levelled on the top with cement (fig. 128).

At points in the floor where the coal should roll to a drying apparatus as automatically as possible holes of the necessary width, usually circular, cylindrical, or funnel-shaped in section, are cut out and

usually lined with cement. The coal is scraped or thrown off the band conveyors above these openings and shot on to conical-shaped heaps

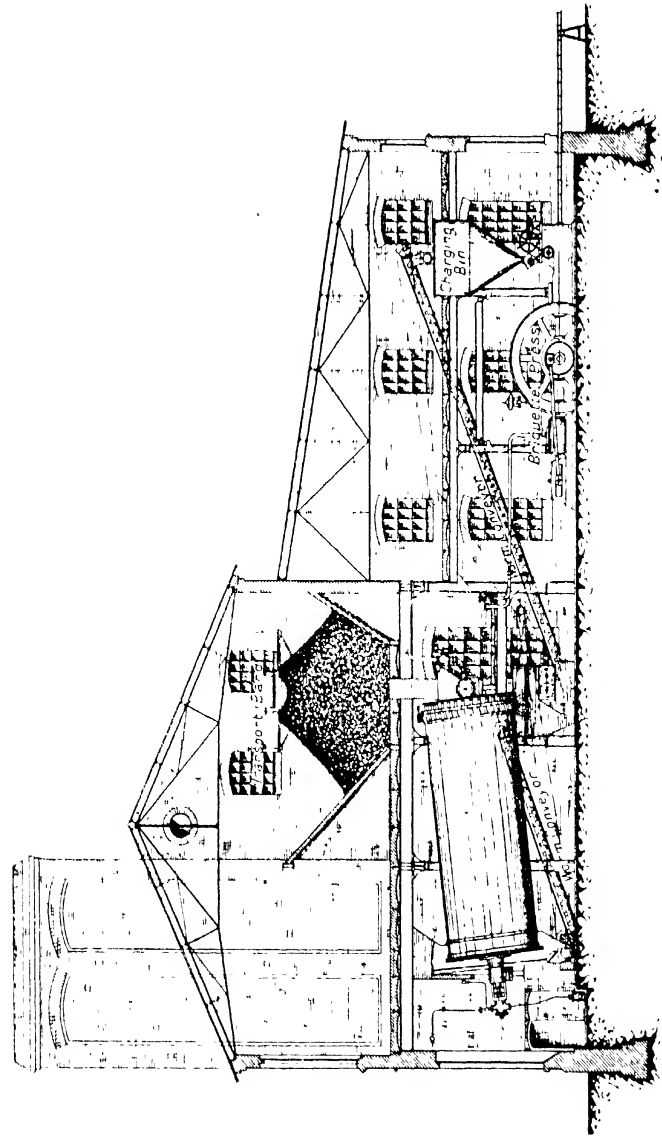


FIG. 128.—Section through the coal store, drying, and press rooms of a briquette factory. Buckau system.

Since in regular working the drying arrangements and presses run continuously day and night, while the mining operations, delivery of coal, and the wet operations only take place for a 10- to 12-hour shift

(day shift), there must be at least twice as much coal conveyed to the coal store as is removed from it during this time. Consequently, the individual heaps gradually grow together. Occasionally a workman with a shovel assists in spreading the coal over the parts of the floor on to which it is not shot directly, especially when the cones stretch almost to the conveyor band.

In the afternoon and night shifts which follow the cellar is emptied again. Funnel-shaped depressions are formed in the heaps over the openings in the floor. If left alone these depressions rapidly increase in depth and width until a maximum is obtained, determined by the size of the opening, the horizontal or inclined position of the floor, the height of the heap, and the moisture and granulation of the mass. Then no more coal slides and rolls down the slopes of the funnel remain unchanged and the drying appliances would run empty were it not for the timely assistance from the source of supply, either by a workman or by some mechanical means. This will be further discussed in the following section.

The automatic sliding with subsequent assistance, is made very much easier if the coal store is provided with steeply inclined smooth brick walls along the two long sides and which has already been carried out in briquette factories built by the Maschinenfabrik Buckau. Fig. 128 shows this arrangement in section. The angle of inclination of the walls must amount to at least 45°. Of course this causes a considerable portion of the available storage space on both sides to be lost, and as a result the store must be of correspondingly larger dimensions to accommodate the necessary quantities of stores, and the conveyor band must be placed as high as possible.

The coal stores require to be amply illuminated, well ventilated by means of open windows, especially on warm and dry days, so that the copious quantities of water vapour given off from the moist small coal can be rapidly carried into the open. In this way a not inconsiderable preliminary drying is obtained without cost under favourable conditions, and a corresponding economy in the subsequent artificial drying by means of steam is effected.

Storage of Boiler Coals.—For the accumulation of the necessary stores of boiler or fire coals, the most suitable arrangement is a brick room above the hopper room, stretching along and of the same length as the boiler-house. Its section is either square with a horizontal floor and discharge openings at the sides, or triangular, pocket-shaped, with the rear wall falling rapidly towards the stepped grate, or, like the

briquetting coal store in fig. 128, it has two walls falling steeply towards each other with the discharge shoots, etc., arranged below. In any case, a completely automatic sliding or rolling of the coals towards the grates must be provided for. Further information on this point is given in Section IX below. A breadth of 3 to about 3·7 metres and a height of double the breadth is, in most cases, sufficient to provide adequate stores for twenty-four hours during the day shift. Charging is generally effected, as in the briquetting coal stores, by scraping or discharge of boiler coals and chips brought from the wet or drying operations by means of an elevated band conveyor (see p. 324), and also by the tipping of waggons containing impure coal obtained from the mine by means of the travelling rotary or top tipper (see p. 325). The tipper track with the tipper can be arranged below or close to the band conveyor. In the first case a very high building, and in the second a very wide storage space, is necessary.

In Section X of this part a number of brown-coal briquetting plants are illustrated and described. Among other things they show a variety of constructions of wet operation appliances and storage rooms for briquetting and boiler coals.

SECTION IV

DRYING THE BRIQUETTING COALS. DRYING OPERATIONS.

A. GENERAL.

THE coal taken from the store has practically the same moisture content as the crude mine moist coal unless a certain amount of preliminary drying has been effected by an adequate ventilation of the store in dry, warm weather. This can always amount to a few per cents., especially during the afternoon and night shift, when the delivery of fresh coal has ceased and only the stock is worked up. Complete information as to the water content of the crude coal is given on pp. 270–272 and p. 277; the necessity for and degree of drying is dealt with on p. 279, and the residual water content of a number of brown-coal briquettes of various origin can be seen from the analytical results on p. 297. Consequently, very considerable quantities of water have as a rule, to be removed from the wet brown coals by the drying operations. The following calculation and tabulated summary will give sufficient information on this point.

Calculation of the Water to be removed by Drying[1] (see fig. 129).

Let

r = the total amount of water (in kg.) contained in 1 kg. of the crude coal (moist briquetting coal).

r' = the residual water contained in 1 kg. of dried briquetting coal.

w = the amount of water to be evaporated per kg. of briquettes.

W = " " " per double load of briquettes.

[1] Partly from Foos, "Der Dampfverbrauch in Brikettfabriken," *Zeit. Braunkohle*, 1907, No. 42.

Then

$1 - x$ = the amount (in kg.) of dry coaly substance in 1 kg. of crude coal

$1 - r$ = the amount (in kg.) of dry coaly substance contained in 1 kg. of briquetting coal,

and

$$1 - r : 1 - x = 1 : 1 + w,$$

or

$$1 + w = \frac{1 - x}{1 - r},$$

and

$$w = \frac{1 - r}{1 - x} - 1 \qquad (1)$$

In order to ascertain correctly the value of W corresponding to the practical conditions, it must first be taken into account that in reality

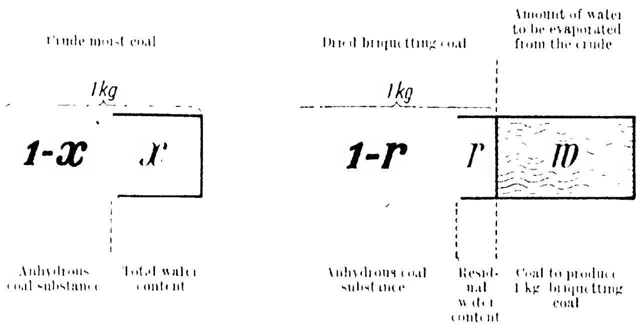


FIG. 129. Diagrammatic representation of the relation between crude brown coal and briquetting coal with regard to the water content or the amount of water to be removed by evaporation.

10,150 kg., corresponding to the previously described 1·5 per cent overweight, instead of 10,000 kg. of briquettes are loaded for a double load.

Further, a certain excess has to be allowed for loss of dry coal as dust and other losses; this loss is estimated as 350 kg. per double load, which is a good average in practice.

In reality, therefore, $10{,}000 + 150 + 350 = 10{,}500$ kg. of dry coal must be prepared for each double load of briquettes, and the quantity of water to be evaporated in this way is

$$W = 10{,}500\,w = 10{,}500\left[\frac{1 - r}{1 - x} - 1\right] \text{kg.} \qquad (2)$$

By means of formulæ (1) and (2) the following results are obtained for the various crude coals with moisture contents between 40 and 60

per cent (x = 0·40 to 0·60 kg.), and a uniform residual moisture content of the briquetting coal of 15 per cent (r = 0·15 kg.)

Total Water Content of the Crude Coal.	Residual Water Content of the Briquette Coal	Amount of Water to be evaporated		
		Per kg. Briquettes	Per double Load (10,500 kg. Briquettes)	
			Total	Increase
x per cent	r per cent	u kg.	W kg.	kg.
40	15	0·4167	4,375	
41	15	0·4407	4,627	252
42	15	0·4656	4,888	261
43	15	0·4912	5,158	270
44	15	0·5180	5,439	281
45	15	0·5455	5,728	289
46	15	0·5740	6,027	299
47	15	0·6038	6,339	312
48	15	0·6346	6,663	324
49	15	0·6667	7,000	337
50	15	0·7000	7,350	350
51	15	0·7347	7,714	364
52	15	0·7708	8,094	380
53	15	0·8085	8,490	396
54	15	0·8478	8,902	412
55	15	0·8889	9,333	431
56	15	0·9318	9,784	451
57	15	0·9768	10,256	472
58	15	1·0238	10,750	494
59	15	1·0732	11,269	519
60	15	1·1250	11,813	544

The last column of the table particularly shows that the amount of water to be evaporated grows with increasing proportion as the total water content of the crude coal increases. This becomes most evident when the upper figures of each column are compared with the bottom entries. The difference in the amount of water to be evaporated from coals with a total content of 40 and 41 per cent amounts to 252 kg., while the difference between 59 and 60 per cent amounts to 544 kg., an increase therefore of almost 300 kg. If the figures of the last column but one be plotted vertically at equal distances from each other on a horizontal base line and the points of the verticals connected together, a gradually rising curve of the form of a parabola is obtained.

The supply of heat necessary to evaporate the water in addition to the still further quantities of heat to be provided (for heating the coal and surrounding air and balancing the loss of the heat by radiation in the drying appliances, etc.), will be further discussed and calculated at the conclusion of the description of the steam drying apparatus.

Since the earthy brown coals of most seams contain over 50 per cent., and many over 55 per cent. even, of water, the production of considerable quantities of heat has usually to be dealt with in the drying operations.

and, in view of the comparatively low selling value of the brown-coal briquettes, it is to be desired that this branch of the work shall be economical, safe, and shall not damage the quality of the material. Above all the necessary quantity of heat must be obtained cheaply, and all unnecessary losses of heat must be prevented as far as possible.

Limits and Difficulties of Drying.—The moist briquetting coal is to be dried as uniformly as possible, and only to that content of residual moisture which has been determined for the particular kind of coal by numerous experiments (see p. 282) or in the actual briquetting operations themselves, and which permits of the production of good domestic or industrial briquettes[1] of the desired properties (compare Section II, p. 286 *et seq.*). Certain difficulties, however, have to be overcome in the attainment of these requirements

The finer grains, and particularly the particles of coal dust, naturally dry much more rapidly than the coarse grains, in which the evolution of water first takes place on the surface and only proceeds gradually in the interior. Therefore every particle of slack or dust, unless withdrawn from the very hot regions at the proper time or surrounded by an atmosphere saturated with steam, becomes super-dried, in which state (as already dealt with on p. 279) it decomposes spontaneously with the evolution of gases and becomes very liable to ignite and explode. Overdrying, with its accompanying dangers, can also occur with coarse grains and charcoal chips, which in some way become entangled in the drying apparatus. If such stoppages do take place, then the risk of fire becomes very great.

The attainment of a uniform and proper degree of drying is also rendered difficult by the unavoidable variations in the water content of the briquetting coal supplied. Coals obtained from open workings which have been exposed to the change of seasons and weather usually show far greater variations of this character than pit coals (see p. 308). Independent of the origin of the coal are those variations in the content of water which are brought about by the coal being brought quite fresh from the wet operations on one occasion, and after a longer or shorter storage and exposure in the coal-store on another occasion, variations which only become more or less obvious with the delivery of one layer per working day (see p. 343 *et seq.*).

It is therefore necessary to adapt previously the drying appliances to the special nature of the coals, and to continuously make allowances

[1] Industrial briquettes can usually carry a somewhat higher content of residual water than domestic briquettes

for the variation in water content during the operation. Above all overdrying and stoppages are to be prevented.

From these points of view, the most important influences are those of the changing *temperature and moisture of the air*.

The steam evolved from the coal in the drying ovens must be removed continuously by a stream of fresh air, which is drawn from the surroundings into the hot interior of the apparatus and the exhaust is usually passed through a system of dust chambers or some other dust-catching arrangement, then through a steam trap (exhaust trap), after which it escapes into the open. But the air cannot take up steam beyond its saturation point, which of course varies with the temperature. The temperature and moisture content of the issuing air is therefore of prime importance.

The quantity of moisture in the atmosphere varies greatly and is seldom as high as it might be at the prevailing temperature. Speaking generally, however, the moisture content rises and falls with the temperature, and, with the exception of deserts, is greater in hot districts than cold, greater on plains than on mountains, greater in summer than in winter, and greater during the day than at night. Further the position of the place, the nature of the ground, the configuration of the bordering countries, the proximity of large sheets of water, especially the sea, the direction of the wind and other circumstances cause many changes.

In the determination of the amount of water in the air two things are taken into account: the absolute and the relative amounts of water vapour in a given space. The absolute moisture is given by the weight of water vapour in grams contained in 1 cubic metre of the air or by the pressure of the water vapour present in millimetres of mercury, with which it is in equilibrium. The absolute highest moisture content (saturation point) is therefore identical with the maximum vapour pressure of the air possible at a certain temperature.

The relative moisture, however, is the ratio of the water vapour contained in the air at the particular temperature to the possible quantity at that temperature (saturation point). It is measured by means of a suitable hygrometer (instrument for determining moisture) in percentages (100 per cent. = saturation point), and can be plotted continuously by means of a hydrograph[1] (see p. 358 *et seq.*).

[1] The relative moisture content of the outside air in Berlin, for example, amounts to 66 per cent. on an average in the summer months and 87 per cent. in the winter months. In Central Germany it averages about 75 per cent. over the whole year.

TABLE I.—SATURATION OR MAXIMUM VAPOUR PRESSURE OF THE ATMOSPHERE FOR TEMPERATURES FROM −30 TO +50° C (ACCORDING TO JELINEK)

(t = temperature of air in ° C, e = pressure in mm. of mercury.)

t	e	t	e	t	e	t	e
° C	mm	° C	mm	° C	mm	° C	mm
30	0·38	10	2·15	10	9·14	30	31·51
29	0·42	9	2·33	11	9·77	31	33·37
28	0·46	8	2·51	12	10·43	32	35·32
27	0·50	7	2·72	13	11·14	33	37·37
26	0·55	6	2·93	14	11·88	34	39·52
25	0·61	5	3·16	15	12·67	35	41·78
24	0·66	4	3·41	16	13·51	36	44·16
23	0·73	3	3·67	17	14·39	37	46·65
22	0·79	2	3·95	18	15·33	38	49·26
21	0·87	1	4·25	19	16·32	39	52·00
20	0·94	0	4·57	20	17·36	40	54·87
19	1·03	1	4·91	21	18·47	41	57·87
18	1·12	2	5·27	22	19·63	42	61·02
17	1·22	3	5·66	23	20·86	43	64·31
16	1·32	4	6·07	24	22·15	44	67·76
15	1·44	5	6·51	25	23·52	45	71·36
14	1·56	6	6·97	26	24·96	46	75·13
13	1·69	7	7·47	27	26·47	47	79·07
12	1·84	8	7·99	28	28·07	48	83·19
11	1·99	9	8·55	29	29·74	49	87·49

Dew-Point.—Air saturated with water needs only a very slight cooling to cause the deposition of water as fog or rain, while unsaturated air, containing the same quantity of moisture at a higher temperature, must be cooled to a considerably greater extent before separation takes place. Dew point is the name given to that temperature at which the atmosphere would deposit a portion of its water vapour in the form of small drops of water (fog) immediately a further slight cooling takes place. In order to determine the dew point, the vapour pressure is first calculated (as follows), corresponding to the temperature and relative moisture content of the atmosphere which have been read off. The temperature at which the above vapour pressure would become the saturation or maximum vapour pressure is then looked up in Table I. (see Example I. given below). The dew-point is obtained more rapidly with the aid of the diagram (fig. 131) given below (p. 356).

Determination of the Vapour Pressure and Dew-Point.—The vapour pressure corresponding to the absolute moisture is calculated from the observed temperature and relative moisture of the air by means of the formula

$$e = \frac{f}{100} E$$

where

e' = the vapour pressure required

f = the relative moisture read off on the hygrometer, and

e = the maximum vapour pressure corresponding to the momentary temperature t.

Example I.—According to readings of the thermometer and hygrometer,

$$t = 20^\circ \text{ C. and}$$
$$f = 55 \text{ per cent.}$$

According to Table I.,

$$\text{at } 20^\circ \text{ C. } e = 17{\cdot}36 \text{ mm.,}$$

and according to above formula,

$$e' = \frac{55}{100} \times 17{\cdot}36 = 9{\cdot}55 \text{ mm.}$$

The dew-point of the air for the temperature and moisture given above should therefore be at about 10½° C. since the pressure 9·55 mm. is the maximum vapour pressure between 10° and 11° C. (see Table I.). Therefore the atmosphere must be cooled down to this temperature before a precipitation of small drops of water can result.

Determination of the Weight of Water Vapour.—In order to determine the weight (p) of the water vapour in 1 cubic metre of air, the vapour pressure e' calculated as above from the observed temperature (t) is simply multiplied by the factor F, which is given against the observed temperature in the following Table II.

$$p = e' \text{ F grams.}$$

Example II.—As in the foregoing example, the atmospheric temperature

$$t = 20^\circ \text{ C.}$$

and the vapour pressure e' determined for the relative moisture $f = 55$ per cent. is 9·55 mm. The weight of water vapour contained in 1 cubic metre of air is calculated by the above method from the formula $p = e'$ F to $p = 9{\cdot}55 \times 0{\cdot}99 = 9{\cdot}454$ grm. (absolute moisture). If, however, the atmosphere is completely saturated with water at the same temperature, so that $f = 100$ per cent., the corresponding maximum vapour pressure $e = 17{\cdot}36$ must be introduced into the formula, and the value $p = 17{\cdot}36 \times 0{\cdot}99 = 17{\cdot}186$ grm. is obtained as the weight of the maximum amount of water vapour which can possibly be present in atmospheric air at 20° C., *i.e.* the weight of the absolute maximum moisture content.

TABLE II.[1]—FACTORS FOR CALCULATING THE WEIGHT OF WATER VAPOUR IN SATURATED OR UNSATURATED AIR IN GRAMS PER CUBIC METER.

(t = temperature of air in ° C., F = factor.)

t	F	t	F	t	F	t	F
° C.		° C.		° C.		° C.	
30	1·19	10	1·10	10	1·02	30	0·95
29	1·19	9	1·10	11	1·02	31	0·95
28	1·18	8	1·09	12	1·01	32	0·95
27	1·18	7	1·09	13	1·01	33	0·94
26	1·17	6	1·08	14	1·01	34	0·94
25	1·17	5	1·08	15	1·00	35	0·94
24	1·16	4	1·08	16	1·00	36	0·94
23	1·16	3	1·07	17	1·00	37	0·93
22	1·15	2	1·07	18	0·99	38	0·93
21	1·15	1	1·06	19	0·99	39	0·93
20	1·14	0	1·06	20	0·99	40	0·92
19	1·14	1	1·06	21	0·98	41	0·92
18	1·13	2	1·05	22	0·98	42	0·92
17	1·13	3	1·05	23	0·98	43	0·92
16	1·13	4	1·04	24	0·97	44	0·91
15	1·12	5	1·04	25	0·97	45	0·91
14	1·12	6	1·04	26	0·97	46	0·91
13	1·11	7	1·03	27	0·96	47	0·91
12	1·11	8	1·03	28	0·96	48	0·90
- 11	1·10	9	1·03	29	0·96	49	0·90

The weight of the water vapour can also be readily obtained from fig. 131.

Hygrometer (instrument for measuring moisture content).—Hygrometers are instruments which show the relative amount of moisture in the atmosphere in per cents. The hair hygrometers are most frequently applied. They depend upon the fact that a stretched hair or bundle of hairs elongates to a greater or less extent in atmospheres showing variations in moisture content and contracts in dry atmospheres. The instruments of C. Koppe and R. Fuess are reliable ones.

C. Koppe's Hair Hygrometer[2] (fig. 130) is the oldest instrument of this type, for the most part designed after the principles of Saussure and consists of a hair whose upper end *a* is fastened to the middle of a stand, while the lower end is twisted round a roller and is kept in tension by means of a small weight. To the roller is attached a pointer which accurately indicates on a circular scale the changes in the length of the hair brought about by increasing or decreasing quantities of moisture in the atmosphere. The two end points of the scale are determined according to the position of the pointer in artificially dried

[1] According to the instructions for using the hair hygrometer issued by Fuess.

[2] To be obtained from R. Fuess, Mechanisch-optische Werkstatten, Steglitz bei Berlin, at a price of about 40 marks, including thermometer graduated in ½° C. and wooden box.

air and in air which has been saturated with moisture and the intermediate length divided into 100 parts (per cents) or degrees of moisture

Testing and Calibrating. The sheet metal plate R, forming the back wall and cover of the case is first removed and then the glass plate forming the front wall and the frame M covered with muslin are

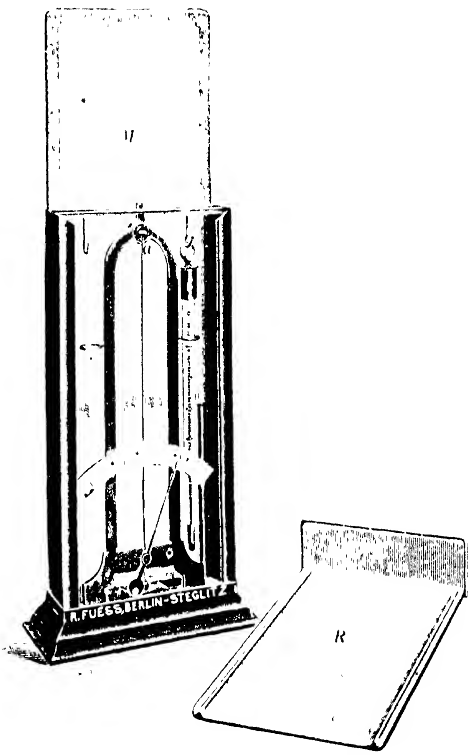


FIG. 150.—Koppe's hair hygrometer. [illegible] natural size.

drawn out. The tension weight and pointer which are arrested when not in use are set free. Now the muslin on the frame is drenched with water and pushed into the grooves on both sides, the glass plate and metal cover are replaced so that the case is completely closed. After the lapse of about ten minutes, the air inside the case will have become saturated with moisture, and then after the case has been shaken by slight tapping with the finger the pointer will stand at 100 per cent, and if it does not the clock key provided is placed on the axis through the hole in the glass slide and the pointer adjusted to

100 per cent. after tapping the case repeatedly. The instrument is now ready for use After the metal slide R and the moist muslin frame have been removed again, the hair contracts after a few minutes and rotates the pointer back again until it corresponds to the prevailing moisture in the atmosphere. This is recognised by the fact of the needle standing still when the percentage indicated is read off. Simultaneously, the temperature is read off by means of the thermometer hanging in the hygrometer case

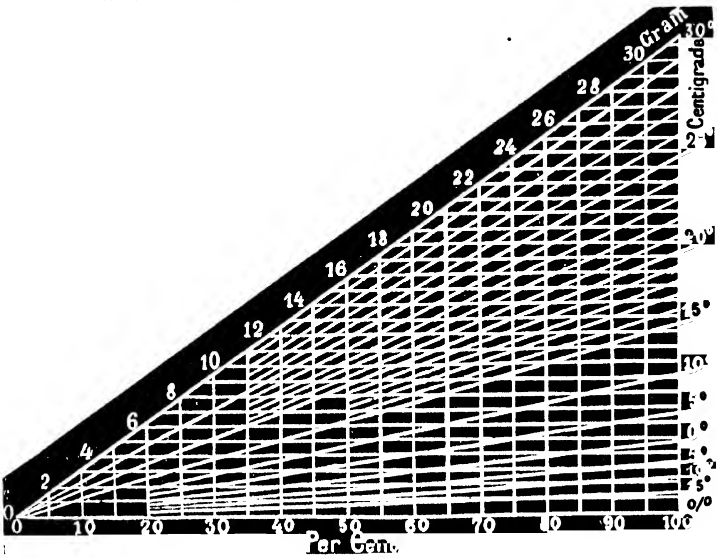


FIG. 131 – Diagram of the derivation of the absolute moisture of the atmosphere from the observed relative moisture and the temperature

The absolute moisture and dew-point are derived from the relative moisture and temperature of the air obtained in this way, with the aid of the diagram accompanying the apparatus, and which is reproduced above, fig. 131. The base line is divided into percentages of relative moisture and the extreme vertical line at the right into degrees centigrade, while the hypothenuse of the large, right-angled triangle shows the maximum amounts of water vapour (in grams per cubic metre) corresponding to complete saturation at the various temperatures. The meaning of the inner horizontal, vertical, and inclined lines and the use of the diagram can be seen from

Example III.—Reading of hygrometer, 55 per cent. } as in Examples
„ thermometer, 20° C. } I. and II. p.353.

The vertical line for 55 per cent and the inclined line from zero to 20° C. intersect in a point situated about half-way between the horizontal lines 9 and 10, *i.e.* there are contained about 9½ grams of water vapour in 1 cubic metre of this particular atmosphere (absolute moisture), and since a horizontal drawn through the point of intersection leads to 10½° C. at the right, 10½° C. is the temperature of

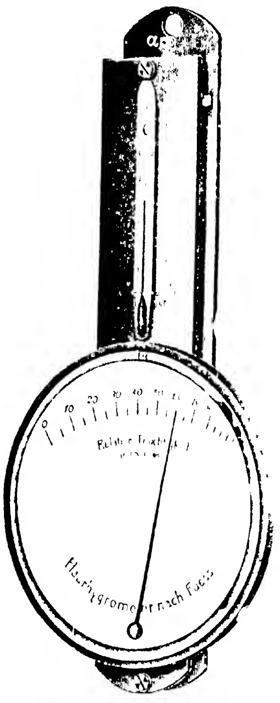


FIG. 132.—Simplified hair hygrometer by R. Fuess.

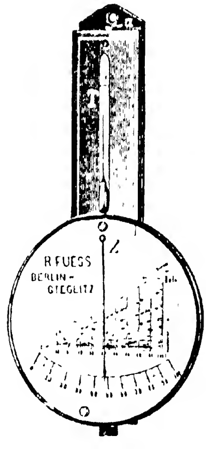


FIG. 133.—Hair hygrometer by R. Fuess (With diagram.)

the dew-point—*i.e.* the air must be cooled from 20° C. to 10½° C. before the separation of water vapour takes place.

It will be seen that both these results are in complete agreement with those obtained above arithmetically.

Simplified Hair Hygrometer, by R. Fuess[1] (figs. 132 and 133).—Between the two vertical metal plates of the instrument the hair rope is fastened by means of a lever to the pointer axle at one side and at the other to an elastic metal sheet which can be moved to and fro by

[1] To be obtained from R. Fuess, Steglitz, Berlin (price about 27.50 marks, including thermometer).

means of the adjusting screw *a*. In order to test and calibrate the instrument, the piece of cloth supplied is moistened with water and wrapped round the metal plates in such a way that the space between them is closed on all sides. After about 5 to 10 minutes the air in the space is saturated with water and the pointer must stand at the "hundred" mark if the instrument is reading correctly. Otherwise it is adjusted to 100 by turning the screw *a*. The instrument is to be hung in such a way that the air has free access to it on all sides. Very dusty air puts it out of action after a short time.

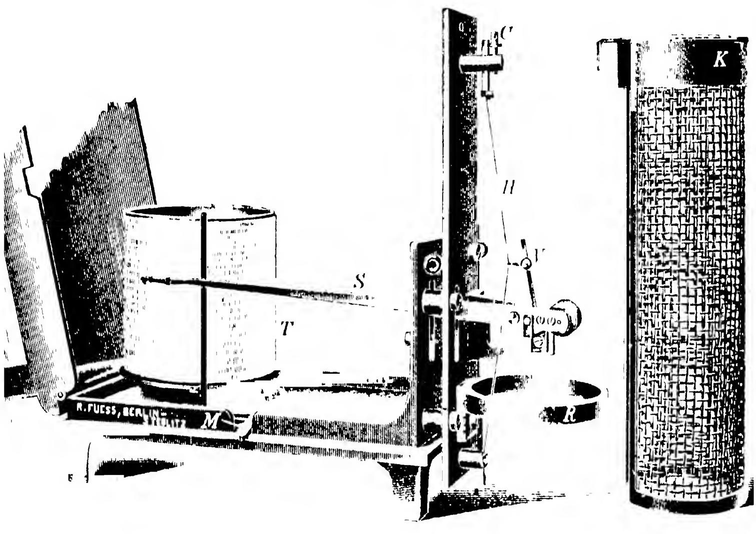


FIG. 134. R. Frère's hygrograph improved by R. Fuess.

In the design represented in fig. 133 the percentage scale and indicator are reversed as compared with fig. 132 and the dial also contains the diagram previously described above (fig. 13), so that the absolute moisture content and the dew-point can be obtained without calculation.

Hygrographs (instruments for registering the moisture content) (figs. 134 and 135).—These are hygrometers which continuously trace the indicated moisture content of the atmosphere on a strip of paper.

In the Frère hygrograph, improved by R. Fuess[1] (fig. 134), the changes of length of the hair-rope H are transferred by a hook V

[1] To be obtained from R. Fuess, Steglitz, Berlin (price about 137 marks, including one year's supply of paper (54 sheets), one bottle of ink, and one spare pen).

to the pen lever S, whose pen transcribes them to the graduated paper attached to the slowly revolving drum T. A clockwork arrangement inside the drum causes it to make one revolution every one, two, or seven days. Before use the pen is adjusted to a particular division of the paper by means of the arrangement C. The shifter M serves to lift the pen from the paper, which is taken off after a complete revolution of the drum and replaced by a fresh piece.

When the instrument is used without interruption a continuous, partly horizontal, partly rising and falling curve is drawn on the strip

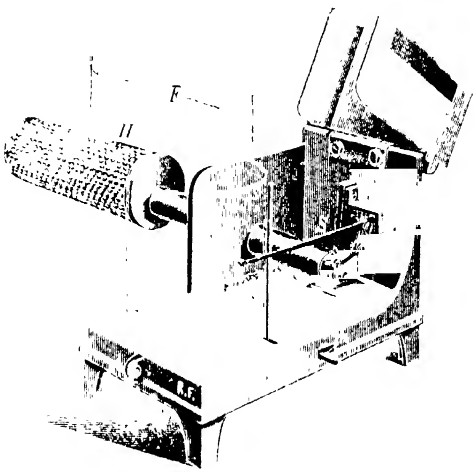


FIG. 135.—Hygrograph with arm.

of paper and shows at a glance the percentage of moisture in the atmosphere during the various hours of the day. The strips are marked with the data and preserved.

In order to protect the hair rope adjusting arrangements and the link, the wire basket (standing to the right in fig. 134), having a long slit at the left, is placed in the ring R and hung from the vertical metal plate of the instrument by the hook at the top of the cover. The hinged-glass cover indicated at the left is provided for the protection of the drum and the pen-lever.

The hygrograph with arm[1] (fig. 135) is specially adapted for drying rooms. One end of the hair-rope is attached to a horizontal

[1] To be obtained from R. Fuess, Steglitz, Berlin (price about 150 marks, which includes one year's paper (54 sheets), one bottle of ink, and one spare pen.

tube and, protected by the wire basket H, can easily be introduced in the space under test, while the box with the registering apparatus is fixed outside so as to be readily accessible. The instrument can be made with an arm length up to 1 metre

In addition to the moisture of the air, the absence or presence of wind (and in the latter case the strength and direction of the wind) also influences the drying operations.

Results of the Foregoing Considerations, etc—1. Because of its higher capacity for taking up water vapour, warm air is better adapted for drying than cold air.

2 It is therefore advisable to warm cold or cool exterior air before introducing it into the drying apparatus (This can be obtained without special costs of working only by the aid of special constructional arrangements which permit of the use of certain quantities of heat produced in the briquette factory which would otherwise go to waste)

3. The passage of the air through the drying apparatus must be regulated in such a manner as to prevent a supersaturation of the air with water and to keep the temperature from falling below the dew-point. A re-formation of drops of water which have then to be evaporated again increases the amount of heat used and diminishes the output of the drying oven

4. In order to be able to take into real account the varying temperature and moisture of the atmosphere in the drying operations, regular (or at least in cases of need) careful observations with reliable thermometers and hygrometers are indispensable Therefore, these instruments should be found in every briquette factory and should always be ready for use.

5. Hygrographs present the special advantage of continually recording the moisture whether it be in the exterior air or the internal atmosphere of the drying room, and in this way provide the best possible means of control.

6 In addition to temperature and moisture content of the air the possible absence or prevalence of wind as well as its strength and direction must also be observed in order to indicate the proper precautions.

The Various Sources of Heat for Drying the Briquetting Coals artificially.—The following are applied as sources or carriers of the necessary quantities of heat for evaporating the excess of water from the briquetting coals:—

Fire or hot gases (mixed with air)	for direct drying
Hot air alone .	" "
Or in combination with steam	partly direct, partly indirect drying
Steam alone .	for indirect drying only

The immediate action of fire gases from the boiler flues or from special grate fires (on coal which is moved forward mechanically in a closed oven by a number of worm conveyor troughs or over an iron table) was considerably extended in the years 1870 and 1880, but is at present limited to a few of the older factories and will soon quite disappear, at all events from Germany, where the new mine police regulations[1] generally forbid the installation of drying arrangements of this description The reason for this lies first in the fact that the lignites usually ignite very easily at temperatures of about 200° C., in the difficulty of preventing the fire gases attaining too high a temperature, and also in the difficulty of keeping the drying oven so constantly gas tight as to prevent the influx of exterior air into the inside of the oven giving rise to an explosive mixture To these dangers, which often give rise to fires and not seldom to explosions, must be added many other evils inaccessibility of the oven interior the contamination of the lignites with flue dust and, during the production of hot gases on special grates, the burning of considerable quantities of coal, of which a considerable portion at least could have been compressed or otherwise set aside as saleable rough coal.

Heated air has also been applied in many briquette factories, and usually in such a way that fresh air was passed through boiler tubes heated by waste steam and the hot blast so obtained blown through the lignite smalls sliding between two curved plates. In one special appliance (Jacobi) it is also subjected to the action of waste steam passing through intermediate tubes With the exception of a few individual cases this method of drying has been almost completely abandoned, principally on account of the low capacity as well as on account of the extraordinary production of dust and many disadvantages caused thereby, and above all because of the great dangers of such working In fact the Kgl Oberbergamt zu Halle has found it necessary to order, in the mine police regulations already discussed (§ 4, Prevention of the accumulation of coal dust, see 6) that the new

[1] *E.g.* according to § 5, No. 1, of the Halleschen Bergpolizeiverordnung of Dec 21, 1903, dealt with on p. 284.

installations of drying appliances operated by means of heated air are only to be applied to the drying of coal with the special permission of the Oberbergamt."

During the last twenty years steam has become the principal source of heat in the place of fire gases and hot air, and is applied in the shape of waste steam from the whole of the presses and other machines driven by steam.[1] Fresh steam from the main steam pipes is added if necessary, but in any case the action is indirect, the steam diffusing its heat to the small coal through the walls of a hollow iron heating appliance. Compared with drying with fire gases or hot air, this intermediate steam drying presents above all the advantage of a much greater security against fires and explosions (the latter are almost totally excluded in modern steam drying ovens with suitable dust-catching arrangements), in addition to a much greater economy in working.

Obviously it is most economical to use waste steam alone in drying since it is to be obtained practically free of cost and would otherwise be exhausted into the open air or condensed in the condensers by means of cold water. The only condition is that there must always be the necessary quantity of waste steam to be disposed of. This will always be the case at briquette factories situated in or close to a large central electric station driven by steam and which allows of the whole or most of the machines (with the exception of the briquette presses) for the operation of the mine and the factory to be driven by electrical energy (further information on this point will be given below in Section IX.)

If, however, the amount of waste steam produced is not enough for drying purposes, an addition of fresh steam is inevitable, although this is a little less economical. Then the high pressure of the fresh steam must first be considerably reduced by allowing it to issue from the main into the drying apparatus through a reducing valve, and in this way the most valuable property of the steam, its pressure, is for the most part destroyed. In the drying ovens only a low or moderate pressure is permissible (up to about 3 atms. super-pressure), simply because the drying apparatus stands in open communication with the waste steam pipes and the cylinders of the presses, etc., and consequently the steam pressure in the apparatus acts as a back pressure

[1] Among these there may be included: the power machines for the wet operations, the drying plant, and the boiler feed; under certain conditions the engines for operating the mines (conveying, pumping water), or for driving a central electric station or a single dynamo used for running the factory or mine.

in every cylinder, to be overcome by the work of the piston or inlet steam at every stroke.

Thermal Changes during Steam Drying.—Indirect steam drying like steam heating depends on the fact that the steam introduced into the body to be dried or heated has to give up its internal or latent heat of evaporation to the walls and their more or less cool surroundings (coal smalls, air) and become itself condensed to water. The so-called "liquid heat" of the steam however remains in this condensed water and is carried away usually to pre-heat the cold boiler feed water and is applied in the boiler plant in the fresh generation of steam.

1. By 'liquid heat'[1] is understood that quantity of heat used in steam generation solely for the purpose of raising the liquid (water) to the temperature corresponding to a certain definite steam pressure.

2. 'Internal heat of evaporation' is the name given to that quantity of heat which is necessary to convert the water heated up to the steam temperature into steam, while

3. 'External heat of evaporation' is that amount of heat corresponding to the work of displacement which has to be provided to make the steam fill the space provided for it.

The sum of these three quantities of heat is generally known under the name 'total heat' and is made up as follows:—

Total heat = liquid heat + internal heat of evaporation + external heat of evaporation, or briefly

Total heat = liquid heat + heat of evaporation.

This heat of evaporation cannot be recognised by the thermometer; it is therefore to a certain extent hidden, hence the name latent heat of steam. That it has not disappeared entirely (with the exception of the external heat of evaporation) but is still really extant in the steam, is best seen in the fact that the internal heat of evaporation is again given up when the steam is condensed to water by cooling.

The whole of the foregoing applies to saturated steam, i.e. steam standing over water and which possesses the maximum pressure corresponding to its temperature. In the following table the pressure corresponding to the temperature, the weight of 1 cubic metre and the number of units of heat[2] or calories making up the three kinds of

[1] R. Vater, *Dampf und Dampfmaschine*, Leipsic, B. G. Teubner, 1905, p. 41 *et seq.*

[2] Unit of heat or calorie is the quantity of heat required to raise the temperature of 1 kg. of pure water from 0° to 1° C.

heat, and the total heat are given for saturated steam of from 0·1 to 20 kg. (per sq. cm.) pressure.

TABLE FOR SATURATED STEAM (ZEUNER)

1.	2.	3.	4.	5.	6.	7.
Pressure per sq. cm (absolute) in kg	Temperature in °C	1 cb. metre of Steam weighs kg	Liquid Heat in Cals	Heat of Evaporation		Total Heat in Cals
				Internal Cals	External Cals	
0·1	45·58	0·067	45·65	539·35	35·41	620·40
0·125	50·00	0·083	50·09	536·25	35·55	621·89
0·2	59·76	0·129	59·89	528·13	36·70	624·73
0·5	80·90	0·306	81·19	511·41	38·58	631·17
1·0 (1 atm.)	99·09	0·587[1]	99·58	497·02	40·13	636·72
1·2	105·17	0·719	105·74	492·21	40·63	
1·4	109·68	0·832	110·52	488·64	40·99	
1·6	113·69	0·943	114·39	485·47	41·32	
1·8	117·30	1·054	118·06	482·62	41·60	
2·0	119·57	1·128[1]	120·37	480·82	41·78	642·97
2·5	127·80	1·435	128·75	474·31	42·42	
3·0	132·80	1·651[1]	133·85	470·36	42·79	647·00
3·5	139·21	1·968	140·11	465·26	43·27	...
4·0	142·80	2·163[1]	144·10	462·43	43·53	650·06
5·0	150·99	2·667	152·48	455·97	44·11	652·55
6·0	157·94	3·161	159·63	450·47	44·58	654·66
7·0	164·03	3·656	165·89	445·65	44·99	656·53
8·0	169·46	4·144	171·49	441·36	45·33	658·18
9·0	174·38	4·629	176·58	437·47	45·64	659·69
10·0	178·89	5·109	181·24	433·90	45·92	661·06
11·0	183·05	5·589	185·56	430·61	46·16	662·33
12·0	186·99	6·063	189·59	427·53	46·39	663·52
13·0	190·57	6·534	193·38	424·66	46·59	664·63
14·0	194·60	7·006	196·14	421·95	46·78	665·69
15·0	197·24	7·477	200·32	419·38	46·96	666·66
20·0	211·34	9·794	215·07	408·23	47·66	670·96

The use of this table for the object indicated above will be explained by two examples.

I. If waste steam issues into the heating body of a drying oven at a pressure, as indicated by the manometer provided, of 1 atm. super-pressure (2 atms. absolute pressure = 2 kg. per sq. cm.), a temperature of 119½° C. exists in the heated bodies and must also exist in the condenser water formed in the apparatus. During the complete condensation of every kilogram of waste steam about 480 calories (internal heat of evaporation) must be given up to the cool surroundings, while about 120 calories (liquid heat) remain in every kilogram of condensed water and are carried away with it.

II. If a mixture of waste and fresh steam is used at a super-pressure of 2 atms. (3 atms. absolute), a still greater temperature is obtained, about 133° C., which is about 13½ per cent. higher than in

[1] 1·128 = ∼ 2 × 0·587; 1·651 = ∼ 3 × 0·587, 2·163 = ∼ 4 × 0·587, and so on.

Example I However, only about 470 calories (about 13 less) are given up to the surroundings per kilogram of mixed steam, while about 134 calories (about 14 more) are carried away per kilogram of condensed water. From these examples, as well as from the whole series of figures in columns 2, 4 and 5 of the table, the following general deductions can be made :—

1 The temperature of the steam increases with increase of pressure, but the rate of increase falls as the pressure rises

2. The amount of internal heat of evaporation given up to the surroundings, however, decreases with increase of steam pressure, while the liquid heat of the steam or the amount of heat carried away in the condensed water increases comparatively rapidly

3. By increasing the steam pressure in the drying apparatus a correspondingly greater radiating heat is obtained, together with a much more rapid heating and drying of the briquetting coal and a higher output of the plant, but at the same time a much greater amount of steam is required than when using steam at a lower pressure

Application of Superheated Steam[1] *in the Briquette Factory* Of late superheated (unsaturated) steam, *i.e.* steam whose temperature has been raised considerably by passing it from the boiler through a system of tubes heated by the flue gases has often been applied in the place of saturated steam for operating the briquette presses and other steam engines The important advantages to be derived from the superheating in the conveyance of steam and the driving of machines will be dealt with later in Section IX At present the only question is whether and to what extent the drying is influenced by the superheating Dealing with waste steam only, a notable influence can scarcely occur, since the waste steam reaching the drying apparatus has nearly always completely lost the original superheat of the boiler steam by cooling in the long steam pipes, and as a result of its work and expansion in the presses or driving machines, and has again become saturated steam whose temperature corresponds to its pressure. As a result, special superheating plants have been installed at many briquette factories for dealing with the waste steam from the machines and heating it to between 200° and 300° C At a few works special firing has been provided for these installations. However, the main object desired, that of increasing the output of the drying, was never attained The explanation of this can be seen from the following consideration

[1] S C. Kegel, "Der Wert des uberhitzten Dampfes in den Trockenapparaten der Brikettfabriken," *Z. Braunkohle*, 1902, No. 12.

Attention has already been called to the more or less considerable quantities of condensed water which are always to be found in the heating members of the drying oven, and whose temperature corresponds to the prevailing steam pressure. If superheated steam is now passed in, it immediately gives up its excess heat to the condensed water, *i.e.* it evaporates condensed water until its temperature corresponds to its pressure—until therefore it returns from the superheated to the saturated condition.

The condensed water must not be considered only as collected on the bottom of the heating member, but also as hanging in drops below the heating surface of the heating members. On account of the large amount of latent heat of evaporation necessary, the volatilisation of this latter quantity of water is amply sufficient to completely dissipate the superheating of the dry steam and to prevent the originally high temperature of the steam striking through the heating surfaces.

From this it follows that superheating of the waste steam effects an economy in the amount of steam used in the drying oven, since a portion of the condensed water is always re-evaporated without raising the temperature in the apparatus and thus increasing the capacity for output.

Moreover, the steam economy is relatively unimportant. If saturated steam at 2 atms. super-pressure (=3 atms. absolute), whose temperature is 132·80 C. according to the above table (p. 364), be heated to about 250° C., the increase of the total heat calculated from the specific heat[1] of saturated steam (=0·48 cals.) amounts to $(250-132{\cdot}8) \times 0{\cdot}48 =$ about 56 units of heat per kilogram, which is only about 6·7 per cent. of the total heat of steam not superheated (647 heat units), and about 11·9 per cent. of its internal heat of evaporation (=470·36 cals.). This slight increase, however, stands in no relationship with high costs of the superheater, especially if provided with special firing. Consequently, instead of economy a considerable increase results in the costs of heating.

The low heat conductivity of superheated steam also opposes its use for heating and drying purposes.

The specific heat of the hot steam is very different at different temperatures and pressures. According to the researches of Professor Bach, an average value of about 0·6 cal. can be taken in the region of the temperatures utilised in steam engines.

[1] Specific heat = the quantity of heat in calories required to raise the temperature of the body through 1° C.

Economically it is always quite disadvantageous to superheat waste steam before introduction into the drying oven. Consequently such arrangements are soon abandoned after their introduction.

Removal of Oil from Waste Steam.[1] The necessary lubrication of the steam cylinders during the operation of the presses and other steam engines results in the waste steam being contaminated with lubricating oil which must unconditionally be removed as completely as possible by means of suitable exhaust steam oil separators before the waste steam is led into the drying apparatus. If this is not carried out the oil is for the most part deposited from the exhaust steam in the drying oven, and on condensation is precipitated on the walls of the heating members in the form of drops, considerably hinders the transfer of heat and at the same time accumulates in the condenser water, to be finally conveyed to the steam boiler, where it again acts disastrously.

Measurements of the flow of heat have shown that cylinder lubricating oil on the boiler plates has a heat insulating effect of 11 to 26 times that of a layer of boiler scale of the same thickness. Therefore $\frac{1}{11}$ to $\frac{1}{26}$ the thickness of oil is sufficient to produce the same effect as boiler scale. The result of feeding with condenser water containing oil has in innumerable cases been the collapse of flues, the bursting or bulging of the water tubes, in addition to a number of other dangers.

There are effective means of removing the oil from the condenser water. However, it is of far greater advantage, especially in briquette factories to remove the oil from the waste steam preferably immediately after or as soon as possible after it has left the steam cylinder, since a most rapid separation of the oil takes place when the steam is very hot. In this way it is also possible to recover the oil so that its lubricating properties are undiminished; consequently, it can be used again for lubrication. Oil separators will be dealt with more fully in Section IX.

Utilisation of the Vapours for Pre-heating the Briquette Coals.[2]—A not inconsiderable portion of the heat applied for drying passes away in the vapours or the mixture of steam air and mechanically suspended particles of coal dust evolved from the drying apparatus. This heat is either allowed to escape into the open through the exhaust valves, or in the more usual methods of extracting the dust from the

[1] Wilh. Ernst (Wien), "Die Vorteile der Abdampfentölung," *Ztschr. der Dampfkesseluntersuchungs- u. Versicherungs- Ges. a. G.*, 1908, and *Z. Braunkohle*, vii. 1908, No. 12, S. 199 ff.

[2] *Z. Braunkohle*, vii. 1908, No. 27, pp. 464–465.

vapours it is destroyed by the water sprays, *i.e.* it is carried away in the waters of the dust slimes.

The very estimable thought of utilising the heat of the vapours for the purposes of drying has led to the use of an ingenious arrangement at the Rodder pit at Bruhl near Cologne, already mentioned (p. 308), in which an equilibrium of temperature between the hot vapours and the cold briquetting coal for delivery to the driers is obtained. The results are that:—

1. The steam is condensed from the waste gases which also deposit the suspended coal dust, and

2. The coal introduced into the proper drying appliance is preheated to a considerable extent and the drying operations are diminished to a corresponding extent.

The appliance will be described later under the dust extraction of briquette factories in Section VIII.

Whether the method has satisfactorily solved the problem of utilising the heat of the vapours on a technical and economical basis still remains to be seen, for at present insufficient evidence has been reported. In any case, with the success of this or any other process with a similar object considerable progress will have been attained to the common good of the whole lignite briquetting industry, which is only to be desired.

Probably the heat of the dried briquetting coal which has not been utilised up to the present will be used for heating the fresh coal or the air introduced into the drying apparatus in spite of the opposing, not inconsiderable, difficulties in the way. Preliminary experiments in this direction have already been made.

The briquetting coal leaves the steam drier at a temperature of about 65° to 75° C., and in certain cases even over 90° C. This is far too hot for pressing, and necessitates a preliminary cooling of from 20° to 30°, and in some cases a greater amount of cooling becomes necessary. In the usual cooling operations, to be described in the following section, the heat evolved from the dried coal is disseminated into the atmosphere and is lost just as the heat of the exhaust vapours was lost previously.

B. THE DRYING APPLIANCES.

According as the heating and drying of briquetting coal—as seen previously, p. 360 *et seq.*—is effected either by the immediate action of fire gases or hot air with the indirect assistance of steam in certain cases,

or simply by the radiant heat of steam, the various drying arrangements, or briefly, driers, are arranged in the following four groups:—

I. Fire-heated driers (furnaces, hot-air ovens).
II. Hot-air driers (hot-air ovens, wind ovens).
III. Hot-air and steam driers.
IV. Steam driers.

The driers belonging to Groups I., II., and III. are wholly the older appliances, which were widely applied and attained great importance in the years 1860 and 1880, but have since become fewer and fewer on account of the grounds mentioned above (p. 361), and except for certain driers of Group III. they have now diminished to a few relics in the old installations. Accordingly, only the more important members of these three groups will be briefly described here with reference to the old literature.[1]

I. Fire Driers (Furnaces, Hot-Air Ovens).

Of the various fire-driers ("mould ovens" and "table ovens" of Riebeck, "cylindrical ovens" of Kubisch, "cupboard ovens" of B. Leutert, "drying ovens" of Kessler, Schmidt, Westphal, and others) proposed or brought to practical application the one which proved the best and existed the longest was the fire table oven of A. Riebeck (fig. 136).[2] This oven, first introduced by A. Riebeck of Halle a. S. at the beginning of 1870, consists, according to a later design, of 14 to 17 annular tables *a* of 3.8 metres external and 1.2 metres internal diameter, and about 140 to 170 square metres total effective surface area, carried by twelve cast-iron columns T arranged round the tables. At the outer and inner edges alternately the tables are provided with rims about 10 cm. high and twelve discharge openings. The whole construction is surrounded by brickwork. Moist coal is fed on to the upper table through two or three openings cut in the roof and provided with sheet-iron hoppers, is slowly carried spirally from the inside to the outside of one table and from the outside to the inside of the next alternately by means of a stirring shaft fitted with two or four radial arms provided with shovels very much in the manner described for pit

[1] R. A. Schultz, "Die Verarbeitung der erdigen Braunkohle zu Kohlensteinen," *Preuss. Zeitschr. f. Berg-, H.- u. Sal.-Wesen*, vol. xxiv., 1875; G. Franke, "Der gegenwärtige Stand der Braunkohlenbriquettes-Fabrikation," *ibid.*, vol. xxxiii., 1884; Preiszig, *Die Presskohlenindustrie*, 1885.

[2] According to fig. 7 in Dammer's *Handbuch der chemischen Technologie*, vol. iv., 1898, p. 28.

coals (compare p. 80 *et seq.* and figs. 29 to 31) or brown coals (see p. 376 *et seq.*, and fig. 141). Finally, the material is discharged from the bottom table to be carried away by a worm conveyor.

Along its whole path the coal is subjected to the heat of the fire gases produced by the combustion of brown coals of low value on a grate. The fire gases rise up a vertical brick channel, and first strike the uppermost table, whence they are drawn downwards in the same direction as the coal, and escape to the chimney at the side through a flue situated below the bottom table.

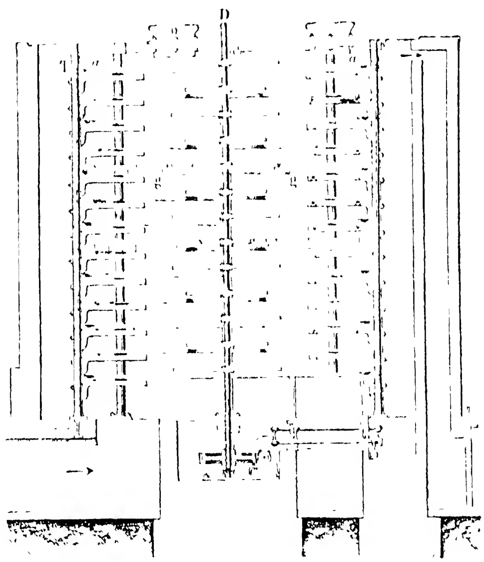


FIG. 136.—Fire-heated table oven by A. Riebeck. Vertical section.

Originally the gases were reversed, travelling from the bottom to the top on the counter-current principle (as in fig. 136) but this had to be abandoned, since the contact of the hottest gases with the driest coal easily led to distillation and ignition (with explosions under certain conditions), so that the table became heated to redness.

In the district of the Halle Mining Commission the special safety regulations[1] for flame ovens already dealt with are in operation.

Flame ovens must be protected against the influx of air, and must be provided with appliances by means of which the coal can be removed without risk in the case of fire in the factory. In addition, the working of the oven

[1] According to § 22 of the Halle Inspection of Mines Regulations for Lignite Briquette Factories, December 21, 1908.

must be as continuous as possible. If interruptions are unavoidable, such as, for example, during risks of fire, the fire must be removed from the grate after closing the damper and the oven first filled with moist coal before being stopped. Steam is introduced for the stifling of conflagrations in the ovens themselves.

By means of a thermometer placed at about a man's height in the side of the oven from which the gases emerge the attendants are enabled to take frequent observations and to maintain a definite temperature varying from 150° to 180° C according to the special conditions prevailing.

Further, the attention of the oven needs special care. With insufficient coal supply the table becomes red hot and irregular in action, the coal lying in the hollows being apt to ignite whereas an excessive coal supply easily leads to stoppages and breakages of the arms. To this must be added the fact that the interior of the flame heated table oven is out of sight and can only be made accessible by a partial destruction of the brickwork.

In 1907–1908 flame heated table ovens were only in operation at the Luise pit Therszen, Hedwig pit Wildschutz, and at the Adolph mine Oberroblingen. Since according to § 5 of the oft quoted Halle Mine Inspection Regulations the erection of new drying appliances in which drying is effected by the direct action of flue gas is forbidden, the use of flame ovens will soon be completely abandoned. Their capacity was by no means low, one oven being usually sufficient to provide a small press of the older type with dried coal.

II. Hot air Driers

The draught oven of Rowold (figs. 137 to 139) has had the widest application of the driers working exclusively with hot air, and is at the same time the oldest member of this system. It is made up of two vertical double series of sheet-metal slides bent to a rounded angle of 145°, arranged in Venetian-blind fashion, as shown in fig. 137, and fixed in alternate similar shaped projections from the wall plates *e*. (In fig. 137 the plates in the central portion of the oven are omitted.)

The two slots *a* serve for the admission of flat plates between which the moist coal introduced above falls on to two plates *b* screwed together so as to form a roof from which the coal slides on to the two exterior plates *c* at both sides. From here the coal slides down in two streams from plate to plate in a zigzag path and is steadily penetrated by the hot air introduced through the slots *d* in the walls

The hot blast fills the oven space and can only escape to the outside by passing through the coal. Finally, the coal reaches the vertical plate *f*, fixed centrally between the plates *e* on both sides, and the discharge arrangement at the bottom. This plate makes the discharge and operation of the two halves of the oven as independent of each other as possible.

The discharge appliance consists of a curved plate arranged horizontally below, and parallel to the longitudinal axis of the oven, and fixed to a shaft about which it can swing slowly to and fro. By adjusting the height of the plates *g*, the quantity of dried coal delivered from the right or left of the curved plate can be regulated according to needs. In the dimensions given here the sliding of the coal in the region of the metal plates is quite automatic if no stoppages occur.

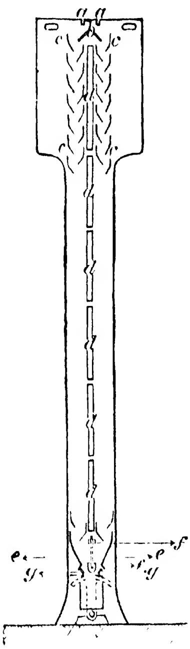


FIG. 137. Rowold draught oven (Hot air oven). Section.

Fig. 138 gives a side view of the wind oven on a smaller scale. *a* denotes the two sheet-iron wind channels which run along the whole length of the oven at the top and have a vertical slit in every oven wall corresponding to the topmost slit *d* in fig. 137.

In front of each individual oven the wind channels are attached to vertical, semi-cylindrical, sheet-iron flue *b*, whose method of attachment to the neighbouring walls is shown in fig. 139. The coal slides between the plates, is carried out at the bottom and falls into a brickwork collecting space of wedge-shaped section, from the bottom of which it is removed by means of a worm conveyor.

The hot blast is produced in a space situated next to or close to the drying house in such a way that one or two fans forces air into a blast chamber and from this through several boiler tubes bricked in with their ends close together and heated by waste steam from the whole of the machinery. Air streams out at a temperature of about 75° to 85° C. and a pressure of about 6 to 8 mm. through a sheet-iron channel into the wind channels *a* and the flues *b* (figs. 138, 139). It then passes through the slits into the various drying ovens as shown above, and emerges saturated with steam and particles of dust as exhaust vapours which escape into the

surrounding space through the exhaust flues or through a system of dust-catchers.

The length of the oven usually amounts to 3.5 to 3.75 metres the breadth 0.4 to 0.5 metre, the effective height 3.5 metres, the number of gliding plates is $4 \times 20 = 80$ to $4 \times 25 = 100$, and the distance between the ovens is 0.5 to 0.6 metre. Between them the collecting space for the dried coal is covered with iron bars laid in the form of a grate. The capacity is very slight, since to provide an old press of about 40 tons daily output scarcely less than twenty presses are required. With all accessories this is a very costly item. Further disadvantages are stoppages and irregular drying can very easily take place, copious development of dust, the difficulty of control of the operation of the numerous ovens is enhanced in the hot drying space filled with dust, the dangers from fire and explosions are increased, and it is more difficult to extinguish the fires. These disadvantages must be added to the others appertaining to drying arrangements working with hot air alone.

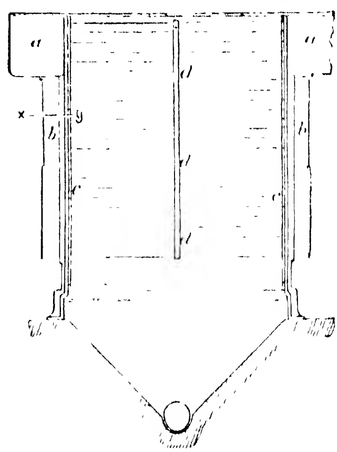


Fig. 138. Rowold draught furnace. Side view (smaller scale).

In the Halle Mining Commission's district special safety regulations[1] are in operation for hot-air ovens.

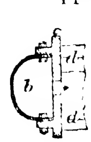


Fig 139.—Horizontal section through $x\,y$, fig. 138 (magnified).

There must be appliances which will permit of the temperature of the air used for heating the drying apparatus being determined at any time. The room in which the blast-heating arrangements and the fans are situated must not be directly connected by means of doors or other openings with the rooms of the factory in which development of coal dust takes place. It is equally important that the drying rooms should not communicate, by means of doors or other openings, with the remaining rooms of the factory. Illumination of the drying rooms must only be effected by lights from which air is excluded.

Further, it is laid down,[2] as already reported on p. 361, that new installations of drying arrangements to be operated by means of hot air

[1] § 21 and § 23 of the Halle Mine Inspection Regulations, December 21, 1903.

[2] § 6 of the Halle Mine Inspection Regulations of December 21, 1903

are only permitted for a preliminary drying of the coal and then only with the special permission of the Mining Commission

In 1908 a total of 134 Rowold wind ovens were still in operation (68 and 66 at the Gewerkschaften Brühl and Roddergrube, Lower Rhineland), but only for drying the sieved rough coal for the production of the so-called Doof briquettes (Holland), while small coal and dust were dried in steam driers and worked up for ordinary briquettes

For rough coal alone the hot-air ovens are undoubtedly better adapted than other appliances, as shown by experience on a qualitative scale These rough coals, containing little dust give, after many hours' drying and compression, pressed coals which hold together even when nearly burnt through, and are consequently in considerable demand in Holland their only market for certain purposes such as the heating of footstools and charging of smoothing irons In addition they are often preferred for heating stoves, although the price of the Doof briquettes is higher than that of ordinary briquettes because of their costly production

For the use of apparatus of almost exactly the same construction as the Rowold wind ovens for cooling purposes see Section V

III Hot-Air and Steam Driers

The best-known and formerly most generally applied member of this group is Jacobi's hot air and steam tube apparatus (fig 140) which is somewhat older than the Rowold oven Instead of the two internal series of metal slides it contains a system of cast-iron steam pipes arranged vertically over each other The coal which is charged in at the top falls past the tubes, is deflected by them to the outside, but is prevented from going too far by a kind of sheet-metal Venetian-blind arrangement. It falls simply by its own weight in a zigzag path to the bottom, where it is led to the collecting space by means of a discharging arrangement like the one used in the wind oven The steam pipes are of five-sided section, with one edge directed upwards, and their ends are alternately joined together at opposites sides of the apparatus, so that the steam (waste steam from the presses and so on) circulates through the system in a serpentine path from bottom to top To the flat underside of each tube two vertical plates are attached in such a way that they form a channel for the circulation of the hot air, which, heated in a special tube apparatus by means of waste steam is forced through the falling coal on each side of the channels by means of a ventilator

and completes the drying and carries away the water vapour. Rough coal is worked up very well but very light-coloured moist coal readily cakes to the heating tubes and not only influences the uniform fall of the upper layers of coal, but also readily gives rise to spontaneous combustions. Further defects are the very low capacity and the very high costs of installation.

In 1907 8 ovens of this description were only in operation at two of the older factories at Bitterfeld. Between 1880 and 1890 Jacobi altered the above design considerably and finally closely approached that of the Rowold oven simply taking over the two series of metal slides and inserting communicating steam pipes provided with heating ribs in the central space filled with hot air. However this system has found little application.

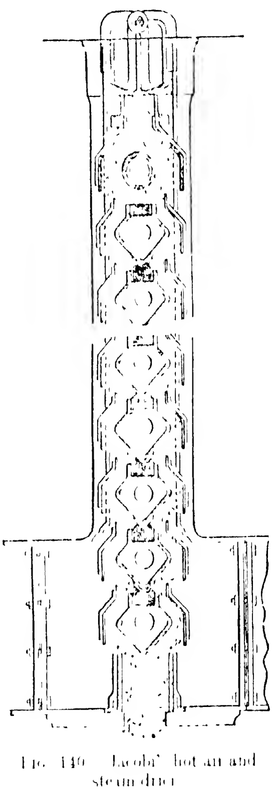


Fig. 140.—Jacobi's hot air and steam drier.

IV. Steam Driers

The system of drying briquetting coals solely with steam was introduced and operated before 1870 along with the other types of driers described above and in the ten years following gained such a complete victory that since that time almost the whole of the new driers built have been steam heated. The stupendous development experienced by the German lignite briquette industry during the last twenty years depends to a large extent on the almost universal application of indirect steam drying. The nature, particularly the origin, pressure, and temperature of the steam for drying (whether waste, fresh, saturated, or superheated steam), carrying out the thermal operations in the steam space of the drier, the utilisation for the purposes of drying and the carrying away of quantities of heat in the condensed water, the necessity for previously freeing the waste steam of oil, and other matters of general interest, have already been dealt with above in detail (pp. 347 to 368). Therefore, it is only necessary to deal with the description and criticism of the most important steam driers in the

following pages These are the steam table drier built by the Zeitzer Eisengieszerei und Maschinenbau Akt.-Ges., and the steam drum tube drier devised by F. A. Schultz and made by the Maschinenfabrik Buckau Akt. Ges. of Magdeburg-Buckau. The few remaining steam driers, such as the steam plate oven introduced at the beginning of 1880 by the Maschinenfabrik Vogel & Co. of Neusellerhausen, Leipsic,[1] and others, have only found such limited application that they can be left out of consideration here. At present they have been outstripped and excelled by the first two systems for a long time.

The Steam Table Drier (Zeitz Table Oven) (Figs. 141 to 149.) – This drier, previously called the steam disc apparatus, was first introduced on a working scale in 1874 by the Zeitzer Eisengieszerei at four installations, at the Bergbau Akt.-Ges. briquette factory, and Gebr. Reschke at Senftenberg, Lower Lausitz. Since that time the number of steam table ovens built by the Zeitzer Eisengieszerei up to the middle of 1908 has grown to about 500, including the not exactly numerous driers for pit coals, peat, and other materials. In recent times the steam table, possibly with slight alterations from the Zeitz design, is built by all other engineering companies making briquetting appliances; still, the old Zeitz works has always maintained its position as chief maker of these ovens by repeatedly and successfully improving its designs.

The use of the Zeitz and Busse-Tigler systems of steam table driers for pit coals is described in Part I., p. 80 *et seq.*, and illustrated by figs. 29 to 31. In any case, they are much better adapted for the much softer brown coals, and under certain conditions are even the most advantageous drying appliances. The new design of Zeitz steam table drier consists of a large number of double-walled, steam-heated, hollow iron discs or steam tables T (fig. 141), which, in addition to an unheated sieve and roll table T_8, are arranged one above the other. At their circumferences they are held by four cast-iron hollow pillars S_1 to S_4 (fig. 142), and each has a circular hole cut in its centre so as to form a shaft-shaped space. In the centre of this space the vertical shaft W of the stirrer revolves; its arms *r* and sheet-iron shovels *s* slowly move the moist coal charged in at the top in a spiral path over

[1] Comprehensive descriptions of this drier are to be found in the papers by G. Franke, "Der gegenwartige Stand der Braunkohlenbriquettes Fabrikation," *Z. f. d. B.-, H.-, u. Sal-Wesen i. Pr. St.*, vol. xxxii., 1884, in the article by Bornstein on Fuel in Dammer's *Handbuch der chemischen Technologie*, vol. iv., 1898, pp. 32 to 33, with figs. 11 and 12; see also *Die deutsche Braunkohlenindustrie*, 1908, ii. p. 27.

the surfaces of the various tables alternately from the inside to the outside and from the outside to the inside until it is finally led away in the dried state at the bottom The action is very similar to that in the flame-heated table oven (p. 370).

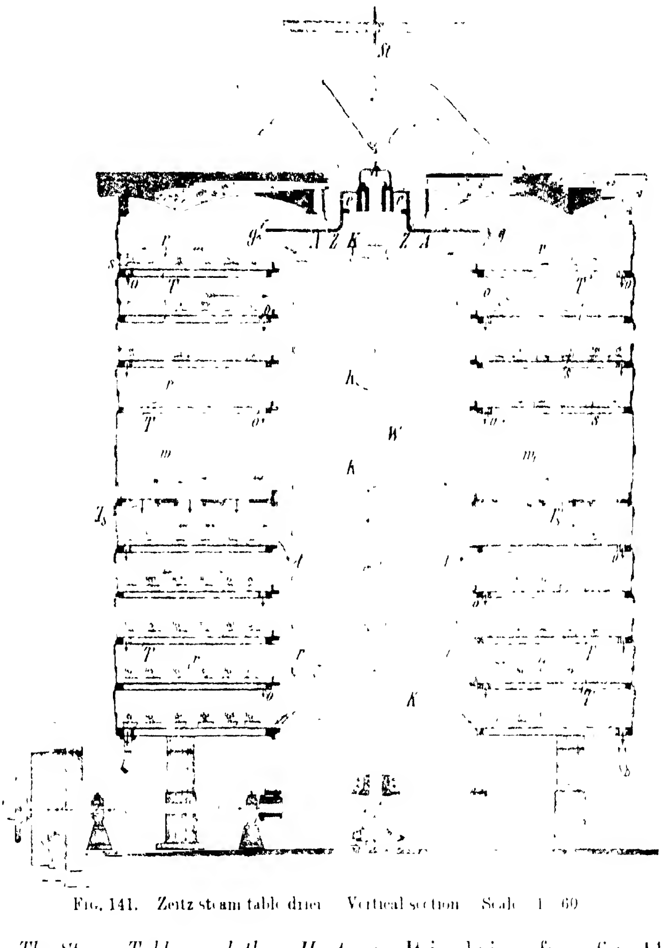


Fig. 141. Zeitz steam table drier Vertical section Scale 1 : 60

The Steam Tables and their Heating.—It is obvious from figs 142 and 143 that the horizontal hollow tables, whose exterior and internal diameters were formerly 3·8 and 1·2 metres respectively, but have now been increased to 5 and 1·5 to 2 metres, are made up of four completely closed sectors of equal size which fit close up to each other and are individually changeable. To resist wear and tear each sector (fig. 143, 1 and 2) has a thick upper plate and a thinner under plate (10 and 8

mm. thick) made of wrought iron or mild steel. A cast-iron rim is laid between the two plates at the edges and the whole closely riveted together, while in the centre seven concentric circles of uniformly distributed rivet bolts at somewhat greater distances (92 in fig. 143), fitted with cast-iron stiffening rings, hold the two plates close together and keep the sector steam tight. The upper heads of the whole of the rivets are flat, cone-shaped, are counter-sunk into the upper plate, and subsequently chiselled and filed level with the surface of the plate.

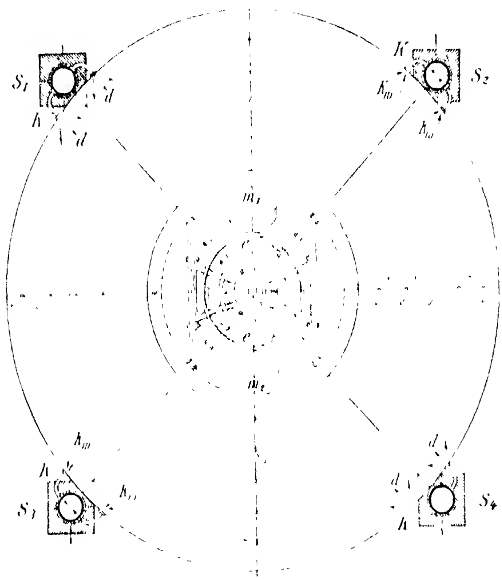


FIG. 142.—Zeitz steam table drier. Plan and horizontal section.[1] Scale = 1 : 60.

The lower rivet heads, however, are of the usual semi-spherical shape (see also fig. 147).

This excessive riveting is essential, since the table sector must remain steam tight and maintain a perfectly flat surface even under a steam pressure of about 2·5 to 3 atms. super-pressure.

Before introduction and hammering over, mild steel rivets must not, like ordinary wrought-iron rivets, be heated to a white heat, but only to a red heat, otherwise there is a possibility of their fracture during the working of the steam table oven.

The inner edge of the cast-iron rim is broadened out into a flange (fig 143) for riveting on an angle-iron segment whose upright side

[1] Discharge openings, stirrers, and driving mechanism are omitted

may prevent the coal being scraped off (figs. 141 and 144). To facilitate the introduction of steam and the removal of condensed water the external cast-iron rim is swollen out close to the junctions of the sectors. Cast-iron plates with central holes de, and an external flange for fixing to the flange of a bent tube K (fig. 142), are introduced at these points.

The plate is represented on a large scale in fig. 143, 3 and 4 being horizontal and vertical sections, while 5 is a front view.

FIG. 143. Sector of a Zeitz steam table.

As shown for a complete table in fig. 142, the hole de in one plate serves for the introduction of steam d into the interior of the table, while the hole in the other plate of the same sector serves for the removal of the resulting condensed water Kw along with a certain amount of steam at the pressure of exhaust.

The other ends of the bent copper tubes K (of 2 to 3 mm. wall thickness) of two adjoining segments are connected by means of flanges to short horizontal connecting branches of one of the four columns S_1 to S_4. At the four bottom tables these connecting branches are provided with stop valves.[1] It will be seen that the two diametri-

[1] Omitted from the diagram.

cally opposite pillars S_1 and S_4 each provide the two sectors fitting together near them with hot steam, while S_2 and S_3 take up the condensed water and waste steam from the sectors and convey it to the steam trap below or to a collecting well under the same pressure as the table (upwards of 1.5 to 2 atms. super-pressure)

In order to determine readily at any time if the lower table is free of water and the steam trap or boiler feed apparatus is working properly, a water indicator designed by Dr Holzberger (Grube Friedrich Wilhelm I. at Costebrau, Lower Lausitz[1]) can be most suitably fitted close to one of the exhaust columns, whose lower portion it connects to the upper table. It consists of a gas pipe connected at the bottom to a water gauge 1 metre high and a stop valve.

In addition, each sector of the steam table is provided with vertical discharge openings *o* (figs 141, 143, and 146), which are situated alternately at the outer and inner edges respectively of two consecutive tables.

Tables discharging the material at the inner edge are provided with $2 \times 4 = 8$, and those discharging at the outside have $3 \times 4 = 12$, such openings through which the coal, brought hither by the shovels of the stirrer, falls on to the table below The distance between the tables generally amounts to 20 cm., the height of fall (= thickness of table + distance) to about 25 cm.

The number of steam tables usually varies from 20 to 32, of which one is the sieve and roll table, which is not heated (see below), according to the water content of the coal to be dried and the temperature of the steam. The heating surface Fh of a steam table, neglecting the discharge openings and the bottom, is equal to the surface area of the outer circle I diminished by the surface area of the central hole (i).

Therefore,

$$Fh = I - i = (D^2 - d^2)\pi/4,$$

where D is the outside and d the inside diameter.

If $D = 5$ metres and $d = 1{\cdot}5$ metres, we get

$$Fh = (25 - 2{\cdot}25)3{\cdot}14/4 = 17{\cdot}88 \text{ sq. metres.}$$

This must be diminished by the total area of 8 to 12 openings. Taking an average of 10 openings, with a total area of about 0.13 sq. metre, the heating surface of a steam table in contact with coal works out to

$$17{\cdot}88 - 0{\cdot}13 = 17{\cdot}75 \text{ sq. metres.}$$

[1] *Z. Braunkohle*, v., 1907, No 13, pp. 682-3, fig. 280.

The total heating surface of a complete steam table drier is therefore

with 24 heating tables equal to $24 \times 17 \cdot 75 = 426$ sq. m.
and ,, 32 ,, ,, ,, ,, $32 \times 17 \cdot 75 = 568$,, ,,

Account must also be taken of the fact that the bottom plates of the table radiate heat, which of course is not so effective as the immediate heat-supply from the top plate, since it can only affect the coal moved over the table below through an intermediate layer of badly conducting air 20 cm. in thickness.

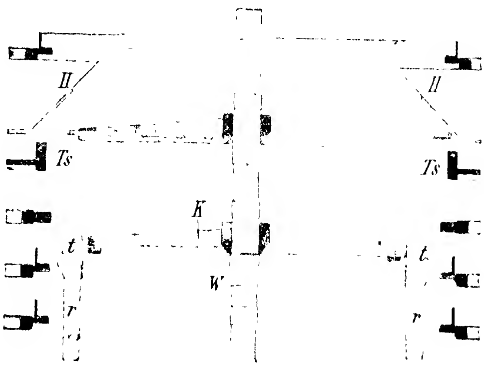
It is recommended, particularly for the working up of coals from open workings, to choose a large number of heating tables in order to have plenty of heating surface available even in cases of an extraordinary high content of water subsequent upon excessive rain. If a smaller heating surface is sufficient in dry seasons, it is only necessary to cut off the steam from the lowest table or the lower tables by closing the stop valves in the bent tubes. Then these unheated tables can serve for any desired cooling of the adequately dried coal moved over them, by means of the exterior air circulating below (cooling tables).

Occasionally the steam table driers are provided, as a matter of course, with a few unheated simple sheet iron sectors (complete discs) forming cooling tables at the bottom. If cooling arrangements are provided elsewhere, the lowest steam table which is not required for drying at the time is taken out of the oven in sectors to avoid unnecessary wear after the removal of the corresponding portion of the stirrer, which can be easily effected.

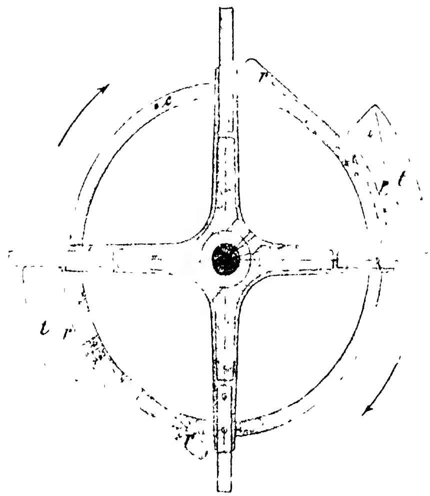
Fig. 147 gives an example of this. We see the bottom portions of three steam table ovens constructed by the Konigin Marien-Hutte of Cainsdorf (Saxony) arranged one after the other. Their principal variation from the Zeitz design lies in the fact that the pillars consist of four wrought-iron or mild-steel tube segments riveted together by vertical flanges, fitted with brackets screwed on, and special pipes behind the columns, with short, connecting branch pipes to the bends for the introduction of steam and for the removal of condensed water and waste steam. The front oven clearly shows that six more tables can be placed on the free pillar brackets and the vertical stirring shaft can be provided with the corresponding crosses and shovel arms below the last visible steam table. Side connecting branches not in actual use are closed for the time being by screwing on blank flanges. Fig. 149, however, shows a drier of the same design in which the whole of the tables are assembled. In the space at the front the columns are

standing ready for the erection of a new oven. Further description of the illustration follows later (p. 391).

The Stirring Gear (figs. 141, 142, 144, and 147).—The vertical main shaft W makes 3 to 6 revolutions per minute, and carries on a thickened



Section



Plan.

FIG. 144.—Main shaft, cross, stirring arms, and coal-dust exhaust appliances of a steam table drier.

portion above each table S a cast-iron cross of triangular section built up of two similar sections bolted together. To the cross are bolted four wrought-iron stirring arms *r* (fig. 141), each carrying a number of removable inclined stirring plates or shovels *s* (fig. 141), standing at right angles to the surface of the table at equal distances from each other. They are fastened either directly below the arm itself, as indicated in

fig. 142 (see also fig. 30, p. 83), or better by means of narrow metal strips attached rigidly or in a hinged fashion to the arms (fig. 141). To the other ends of the strips, plate shovels are bolted and trail after them as trailing shovels during the rotatory motion of the arms.

The attachment by means of strips is to a certain extent more advantageous, since it takes up the gradual wear of the lower edge of the shovels; the metal strips attached to the arms are simply bent down from time to time in order always to allow the shovels to rest on the surface of the table. In the case of the hinged strips this is effected merely by virtue of the weight of the trailing shovels, which

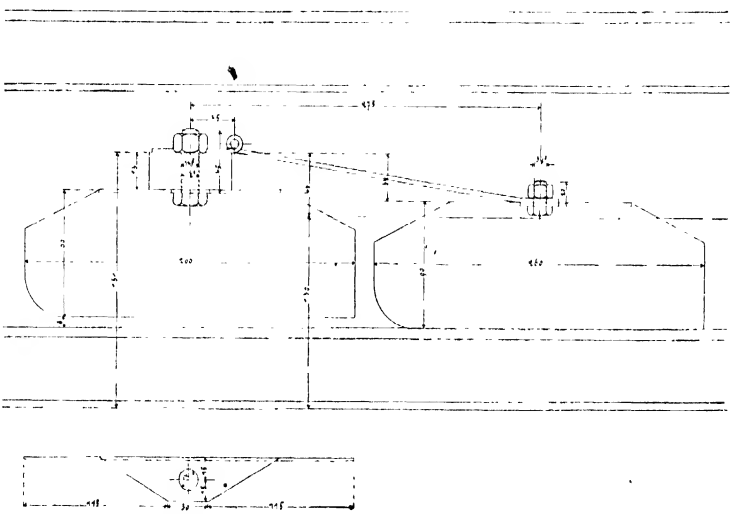


FIG. 145.—Double arrangement of shovels on the stirring arm of a steam table drier.

is of distinct advantage. The shovels are metal plates of a few millimetres in thickness and bent to a right angle. Their customary shape can be seen from fig. 145, which also illustrates the double arrangement of the shovel plates often met with, more especially on the lower tables.

The left plate is rigidly bolted immediately to the stirring arm (represented in section), while the right plate is attached by means of metal strips and hinges and acts as a trailing shovel. By means of this double arrangement a thorough turning of the already partially dried coal is effected, for, while the leading plate shovel no longer quite touches the table after a certain amount of wear, and only pushes aside the coal particles of the upper layers, the trailing shovel which follows moves and displaces the residual coal of the lower layers in a similar manner.

The position of the shovels depends on whether the coal has to be moved in the well-known spiral path towards the discharge openings of the inner or outer edges. For transport towards the interior the plates make an acute angle, and for exterior transport an obtuse angle with the rear side of the stirring arm. In any case, the last plate running next to the inner or outer edge is placed in a suitable converging direction with the neighbouring shovel so as to form an acute angle to take up the coal in front and completely scrape it off into the next discharge opening. In this way the coal is prevented from remaining on the edges and becoming over-dried.

The number of shovels on the upper tables usually amounts to 9 or 10 and often more, while above the lower tables there are 15 to 16 shovels on each stirring arm with the simple arrangement. Consequently, there is a total of 1500 to 2000 shovels in a tall steam table drier with about 24 to 33 tables.

The material which has proved to be the best for making the shovels is the softest possible (Swedish) wrought iron. In the modern briquette factory of the Eintrachtwerke, Lower Lausitz, the shovels made of this material last on an average for 1½ years at about 5½ revolutions per minute of the stirring arms, while in the older factories at a speed of about 3 revolutions per minute they last about three years before requiring changing and repairing. This is effected by cutting off the worn edge and riveting on new metal strips to bring the shovels to their original heights.

The usual method of attachment of the stirring arms to their particular cross, illustrated in fig. 144, has the disadvantage that a breakage of the arm affects the whole of the cross piece concerned, with the result that the whole half of the cross has to be replaced. This is obviated by the application of the cross arms with removable flange attachments designed by Brednow, works manager of the Beiszel pit near Cologne, and constructed by the Holner Eisenwerk und Apparatebauanstalt of Bruhl.[1] The cross section is chosen so that only the flange breaks under great stresses.

The Supply Arrangement (figs. 141 and 142).—The supply of fresh coal from the coal store is carried out by the main shaft as follows:—The upper cast-iron cross K carries two hooked-shaped gripping arms *g* bent upwards and extending horizontally inwards, above two opposite stirring arms. Below the hooks are fixed some inclined sheet-iron scrapers which glide over the circular cast-iron supply-table A, take up the coal fed on to the table through the annular feeding opening *e*, and

[1] *Z. Braunkohle*, vii., 1908, No. 7, p. 119, fig. 61.

scrape it over the edge of the table to fall close to the inner edge of the upper steam table. The constant removal of coal from the supply table results in a steady fall of fresh coal from the heaped-up stock above, which, of course, must always be immediately replenished (cf. pp. 343 to 345). A removable iron dome *h* prevents the elevation of the main shaft head by the pressure of the coal.

A sheet-iron cylinder *z*, which forms the outer edge of the annular charging opening and which can be moved up or down according to requirements by means of a triple-armed adjustment *St* carried above by a spindle, serves for the regulation of the coal-supply. When the cylinder is fixed low a small amount, and when high a larger, quantity of coal is supplied to the supply table.

Appliances for Sieving away Dust, Crushing Coarse Pieces of Coal and Removing Charcoal Splinters, Basty Particles, and other Foreign Materials (figs. 141, 144, and 146).—For this important purpose the new Zeitz steam table driers (Mann's patent) are provided with an unheated sieve and roll table Ts and two iron rolls w_1 and w_2 (fig 141) up to 25 kg. in weight, below the 7th, 8th, 9th, or 10th (or even lower still) steam table, according to the low or high moisture content of the coal to be dried. This table is intended to deal with the finer particles of coal which are sufficiently dried after traversing some of the tables. They are then separated from the coarser particles requiring further drying, and by this means over-drying and unnecessary loading of the lower tables are prevented (see also p. 350). Further, the coarser particles are crushed to a certain extent in order to accelerate the drying and relieve the presses, and the residue of the coarse charcoal splinters, fibrous particles, and foreign materials not adapted to pressing, which were not separated in the wet preparation are removed as completely as possible This is effected as follows —The coal falls from the steam table immediately above on to the inner edge of the sieve and roll table Ts (fig 141), which also catches the whole of the coal falling over the inner edge of the top table with the aid of the conical sheet-metal cap H (fig. 144). The table Ts contains three concentric annular sieves (A, B, and C, in fig. 146, representing a sector of a table, magnified) made of sheet iron containing square holes 3×3 mm. in the inner ring and 8×8 to 10×10 in the others.

Between the sieves the annular cast-iron roll paths *w* and w_1 are situated. The coal is first scraped spirally over the inner sieve C by the inner shovels of the stirring arms revolving immediately above

the table, when the dust falls through the holes on to the steam table below. Coarse pieces, however, pass on to the roll path to be lightly crushed by the conical roll w_1 (fig. 141), dragged after the stirring arm by means of a bent bar, and to be conveyed to the second sieve (the central one) by the corresponding shovels of another stirring arm. This sieve allows the sufficiently small particles to pass through while the coarse particles still remaining travel on to the second roll

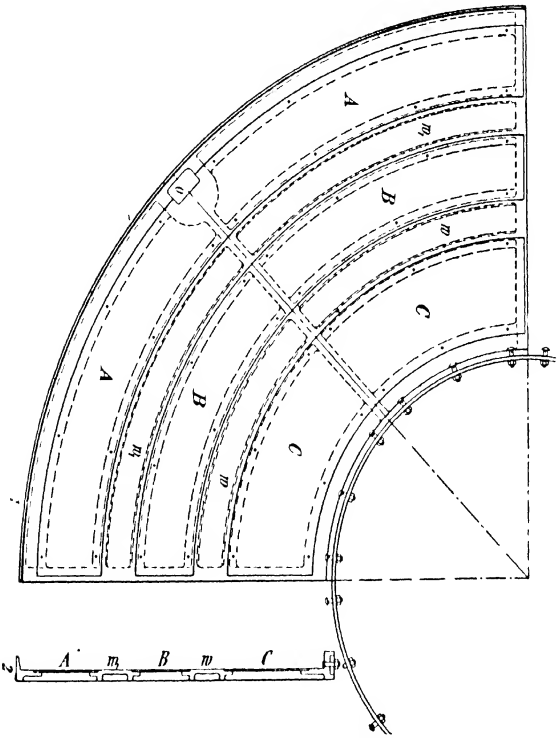


FIG. 146.—Sector of the sieve and roll table of a Zeitz steam table drier.

track where they pass under the second roll w_2 (fig. 141) for further crushing. On the third or outer sieve the last sieving of the fines is completed with the aid of the shovels, which also remove the woody splinters, fibrous matters, etc., left unchanged or insufficiently crushed by the rolls. They are scraped through the discharge opening O (fig. 146) and fall through sheet-metal pipes into sacks or other containers below which are emptied from time to time.

In order to save wages, in the modern table ovens the removal of the woody and fibrous chips is effected through several openings and

inclined pipes into a worm conveyor for chips running along the back of the oven for conveying the whole of the waste in the direction of the boiler-house.

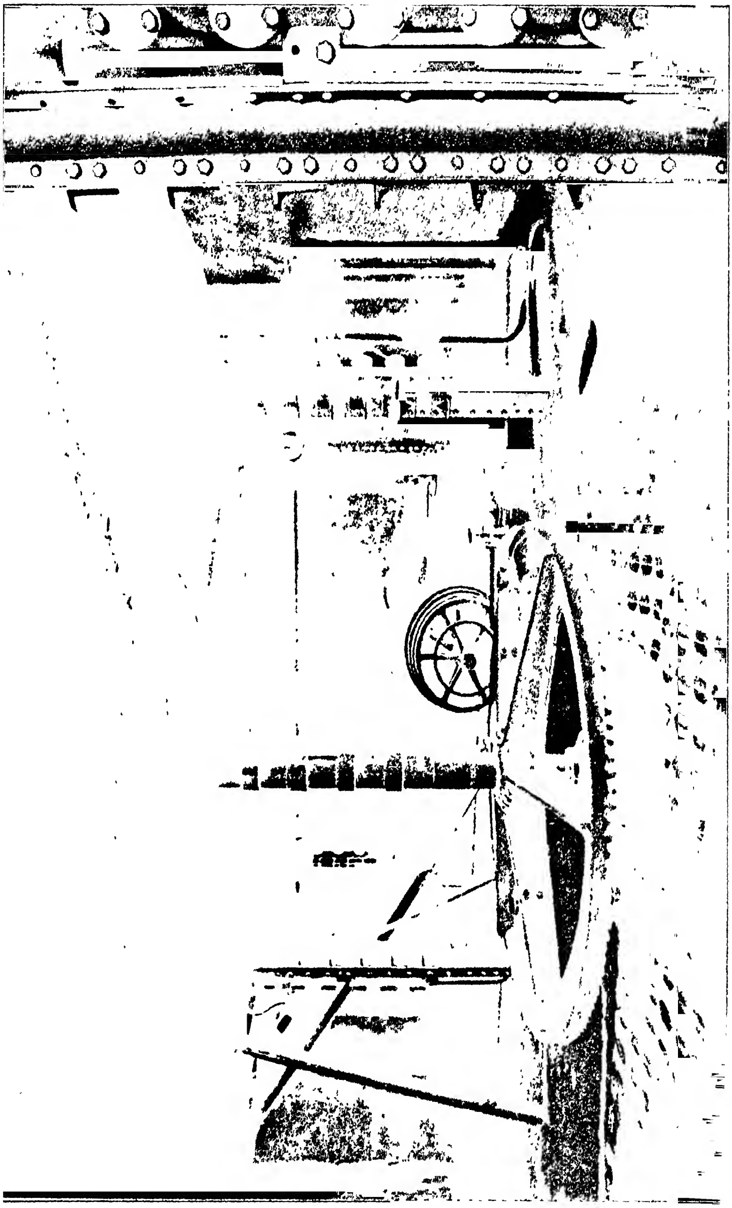
The steam table immediately below the sieve and roll table receives the sufficiently dried coal dust under the first sieve and the pieces for further drying below the middle and outer sieves. While the latter is moved towards the outer edge of the corresponding shovels (about $\frac{2}{3}$ of the total number), the fine coal is conveyed simultaneously by the remaining third of oppositely inclined shovels, and delivered over the free inner edge into the bent hopper *t* (figs. 141 and 144), fastened to two opposite arms, or better, to the four arms of the stirring cross immediately below, and carried round with it during the rotation of the shaft. From the hopper *t* the fine coal slides down inclined tubes *r* on to the lowest table, where it is combined with the sieved coal from the middle and outer sieves after passing over the intermediate tables. The whole falls through the discharge pipes (fig. 147) at the outer edge of the table into the dry coal worm conveyor (oven conveyor)

The drive of the stirrer is effected in the manner depicted in figs. 141 and 147 below the lowest table by means of a large gear-wheel keyed on to the main shaft and a small bevel-wheel whose shaft, situated in two bearings, carries at its far end a three-speed cone pulley and a friction coupling which can be thrown in or out of gear by the revolution of a hand wheel.

This arrangement permits a gradual starting of the stirrer, prevents fracture of one or other of the shafts under excessive demands as a result of the breakage of the crosses or stirring arms, simply by partial over-winding of the frictional resistance of the coupling, and, within certain limits, permits of a simple changing of rotatory velocity by putting the driving belt on to a larger or smaller pulley.

The driving of the various stirrers of a briquette factory is effected either by a common long transmission shaft set in rotation by the dry operation machine in the engine room, or by a special small machine such as an electric motor. Single drive, especially by electric motor, has been continually developed of late because of its great advantages. In the beginning the individual motors were simply placed close to the drier concerned in the open drying room, but in view of the modern mine inspection rules[1] this is only permitted on condition that the electric motors are housed in special air- and dust-tight pro-

[1] Bergpolizeiverordnung des Kgl. Oberbergamte Halle, Dec. 21, 1903, § 9, I.



tecting cases on the grounds of safety. Since other electric motors, regulating appliances, safety appliances, resistances, etc., only need to be installed in such rooms where a development or entrance of coal dust is excluded, the motor with accessories is, in modern factories, installed in brickwork rooms behind the drying ovens, provided with an iron swing door, the motor effecting the drive of the stirrer by means of a short transmission shaft.

In this way the single drive loses above all in distinctiveness, and in addition the control of the various motors, with their keeping in good condition, is rendered more difficult.

The power required for an old steam table drier of small design amounts to about 5 to 6 H.P., but for a big modern oven (with 32 steam and 1 sieve and roll tables) to about 9 to 10 H.P. according to whether the working is normal or very heavy.

The direct rotating pole motors by Siemens-Schuckert are specially adapted as driving motors They usually take about 13 amps. or 17 amps. when fully loaded at 500 volts, and yield therefore $500 \times 13 = 6500$ watts or $\frac{6500}{736} =$ about 9 H.P. to $500 \times 17 = 8500$ watts or $\frac{8500}{736} = 10{\cdot}2$ H.P. Under certain conditions they may be loaded considerably higher, even up to 30 amps.

They have a spark-free motion at the various velocities up to 1200 per minute, corresponding to six revolutions of the stirrer, and are provided with regulating starters and adjusting resistances.

The output of an old oven reaches 35 to 40 tons, but of a modern oven upwards of 53 to 75 tons of dried coal in 24 hours, corresponding also to the output of an old small press or a modern big press respectively. With an available heating surface of 568 sq. metres (see p 381) in the largest ovens, therefore, up to 130 kg. of dried briquetting coal result from each square metre of heating surface per 24 hours.

Covering the Table Driers (figs. 141, 148, and 149).—In order to prevent loss of heat by radiation, and the passage of dust from the steam drier into the drying room, it is necessary to close the intermediate spaces between the tables up to the air-entrance and vapour-exit openings with a cover. However, this must be movable and capable of being easily opened at certain places so that the air-supply can be stopped, increased, or diminished; the work of the individual tables controlled by inspection and the taking of samples at any time; possible deficiencies in and damages to the stirrers and tables recognised and rapidly rectified, the necessary renewals carried

out without the expenditure of too much time and trouble, and any possible conflagrations in the interior of the oven rapidly extinguished.

These various requirements are fulfilled to a large extent by the Rowold sheet-iron cover with section catches and adjustable slides,

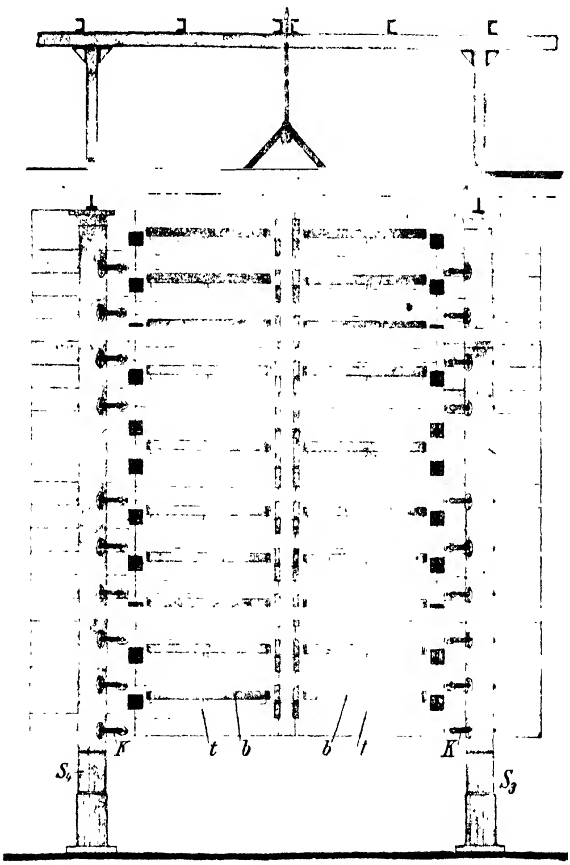


FIG. 148.—Covering of a Zeitz steam table drier by sheet-iron doors with air slots and slides. Scale = 1 : 60.

patented in 1885, and also by the equally old Zeitz covering by sheet-metal doors, with air slots and slides, illustrated in figs. 141 and 148. The individual intermediate spaces between the tables are surrounded by two narrow sheet-metal doors bent to the curve of the table and overlapping to a certain extent above and below. They are hinged on to pins on vertical flat rails fixed to the columns at the right or left, while their other ends can be fixed to

a broad central rail by means of hooks or catches. The sheet-metal doors must open outwards, and when necessary can easily be removed. In addition they permit of the entrance of air without opening the door by virtue of the horizontal air slots fitted in front with vertically adjustable sheet-metal slides.

Fig. 149 shows a Cainsdorf design of steam table drier with the sheet-metal doors without slots and slides, a construction which is often carried out in Zeitz ovens. Above the lowest two tables the doors are removed so that outside air can enter here as well as above the third and sixth tables from the bottom, where the doors to the right are left open. In this drier the pillars with the vertical pipes standing behind (for steam and condensed water) and the pipe bends are also covered with sheet-metal lagging for almost the whole of their height, so as to limit as far as possible the unavoidable loss of heat by radiation from this important part of the oven.

The upper half of the oven is made more accessible by means of a staircase and a staging. For examination of the highest table of the lower or upper half a ladder placed either on the floor or the staging is employed. If, however, such a stage is non-existent, which is often the case, a number of ladders of various sizes must be available.

The very important regulation of the air-supply is generally the task of the briquette manager. This is influenced by the varying water content of the coal to be dried, the strength and direction of the wind, as already laid down in the general part of this section (pp. 347 to 350).

If the air entering the oven is naturally warm or preheated in the briquette factory, and is relatively dry, or if a strong wind is blowing, only a few sheet-metal doors or air slots need be opened and are best opened on the side of the oven opposite to the exhaust ports.

Warm air can be obtained simply by installing the ovens above the presses, so that the air which is not inconsiderably heated by radiation in the press room can rise up to the oven room through holes in the floor. This provides a great advantage over installing the ovens on the ground floor.

Exhaust of Vapours.—For the removal of vapour from the modern steam table drier, a square-shaped brickwork space, situated between the rear columns and usually covering $\frac{1}{4}$ or $\frac{1}{5}$ of the circumference of the oven at the back, is sufficient. In older installations it is continued as a vertical vapour chimney into the open air above

FIG. 149.—Cainsdorf design of steam table drier with simple covering doors and bricked-in oven conveyor.

the factory roof, but in the modern plants the vapours are passed through a system of dust-catchers previous to passing to the chimney communicating with the open air.

Originally the steam table ovens had a central vapour flue forming a continuation of the hole in the middle at the top, the crude coal-supply being arranged sideways. This arrangement, however, did not prove very successful especially in unfavourable weather (formation and deposition of condensed water from the vapours, entrance of rain and snow into the oven, resulting in stoppages and diminution of the output). According to experiments made at the Grube Marie I. at Reppist, Lower Lausitz, such a drier only gives 85·7 per cent. of the quantity of dried coal given by an equally large table oven with side exhaust and central feeding arrangement

If the steam table driers, as is the case at many even modern works, have about half or the greatest parts of their heights open, *i.e.* unprotected, the side exhaust (with a central supply) is limited to the upper portion of the oven, and in the lower portion the central opening in the tables round the main shaft serves as a flue for the ascent of vapour.

Further information on the exhaustion of and dust extraction from exhaust vapours will be given in Section VIII.

Distribution of Heat in a Steam Table Oven and Proposals for the Improvement of Steam Table Driers.—Under this heading, W. F. Randhahn has communicated to the *Zeitschrift Braunkohle* [1] some very valuable considerations based on definite working conditions and a series of experiments. The more important points are repeated in the following pages.

In the first place, it was necessary to lay down a method of research to obtain as conclusive as possible a representation of the method of working of a steam table oven, particularly with regard to the distribution of heat, in order to approach nearer to the problem of diminishing the heat losses as well as the useful heat required in these driers, thus effecting an economy in the steam used, which at many works forms a considerable part of the total costs of briquetting

I. The Distribution of Heat.

A steam table oven 6·4 metres high, 5 metres exterior and 2 metres interior diameter, with 25 steam tables was employed. The maximum continued output from seven such ovens was dried coal for a total of 380 tons of briquettes per 24 hours, and therefore 2262 kg. briquettes containing 14 per cent. moisture were obtained from each oven daily.

[1] 1907, vi, No 24, p. 417 *et seq*

This corresponds to 2210·5 kg. of dried coal with 12 per cent. moisture, the lowest ascertained on the last table heated with steam. Assuming a 5 per cent. loss of coal dust[1] arising in the dust extraction and blow of the stamp, the hourly requirements of each oven amounts therefore to:—

Dry coal . .	2327 kg. with 12 per cent. water.			
Moist crude coal .	4451[2] „	54	„ „	(average).
Water . . .	2124 kg. evaporated.			

During the experiments under consideration the vapour pressure in the oven was 2·3 atms. (absolute), the steam temperature was therefore 124° C. (compare table on p. 364), and the available heat in the steam (inner and external heat of evaporation[3]) = 519·428 calories per kg.

Measurements made in summer showed that the circulating air had a temperature of 21° at the bottom, 34° at the top, and 26° at the middle. In the oven itself it appeared that a uniform temperature of 57° (measured in the exhaust flue) prevailed. The degree of saturation of the air was 72 per cent. For Central Germany the average yearly temperature can be taken as 8° and the average relative moisture 75 per cent. (p. 351, footnote).

Calculation of the Heat Requirements and Losses.

A. Effective Heat used.

The temperature of the coal above the oven was found by repeated measurements to average 16°, therefore the water to be evaporated from the coal must be heated from 16° to 57° and evaporated at that temperature. Therefore each kilogram of water requires:—

Liquid heat	57·121 − 16·006 = 41·115 cals.
Heat of evaporation at	57° = 566·763 „
Total . . .	= 607·878 cals.

Since the oven evaporates 2124 kg. of water per hour, the total amount of heat required amounts to:—

$$Q = 2124 \times 607{\cdot}878 = 1{,}291{,}105 \text{ cals.}$$

[1] In reality the loss is higher rather than lower.

[2] The method of calculation can be seen on pp. 100 to 101 and pp. 347 to 349 of this book.

[3] According to Randhahn, the external heat of evaporation (here about 42 cals.) is reckoned with the available heat of the steam, whereas according to R. Vater (*Dampf und Dampfmaschine*, p. 383) only the internal heat of evaporation is given up again on condensation.

B. Heat Losses.

1. *Heating the Coal.*—The residual water in the dried coal $=\frac{2327 \times 12}{100}=279 \cdot 2$ kg. must also be heated from 16° to 57°, requiring a heat expenditure of:—

$$q_1 = 41 \cdot 115 \times 279 \cdot 2 = 11{,}481 \text{ cals.}$$

The dry substance (like coke) has a specific heat[1] of 0·2031, so that it requires for heating purposes:—

$$q_2 = \frac{2327 \times 88}{100} \times 0 \cdot 2031(57 - 16) = 17 \cdot 052 \text{ cals.}$$

Therefore the total heat required for heating coal amounts to

$$Q_1 = q_1 + q_2 = 28 \cdot 533 \text{ cals.}$$

2. *Heating the Drying Air and Waste Air.*—At 8° 1 kg. of saturated air contains 0·006572 kg. water, and with a degree of saturation of 75 per cent. therefore it contains 0·004922 kg. The exhaust air may contain 0·106047 kg. at 57°, but with a degree of saturation of 72 per cent. it only contains 0·073355 kg., and the difference between these two figures (0·071426 kg.) gives the amount of water carried out of the oven by each kilogram of air. Therefore the amount of air necessary to remove 1 kg. water from the oven is:—

$$\frac{1}{0 \cdot 071426} = 14 \cdot 0 \text{ kgs.}$$

and consequently, for the hourly evaporation of 2124 kg. of water, each oven requires:—

$$14 \times 2124 = 29{,}736 \text{ kg of air.}$$

With a relative moisture of 72 per cent. 1 cubic metre of air weighs 1·044 kg. at 57°. Therefore 28,470 cubic metres of air circulate through the oven every hour, or 7·91 cubic metres every second.

These 29,736 kg. of air must be heated from 20° to 57° and with a specific heat of 0·2375:—

$$q_1 = 29{,}736 \times 0 \cdot 2375 \times 37 = 261{,}300 \text{ cals. are necessary.}$$

The $29736 \times 0 \cdot 004929 = 146 \cdot 6$ kg. of water originally present in each hour's supply of air must also be heated, and require for this purpose:—

$$q_2 = 146 \cdot 6 \times 37 = 5678 \cdot 6 \text{ cals.}$$

Therefore the total heat used for warming the air is—

$$Q_2 = 266{,}979 \text{ cals.}$$

[1] The quantity of heat required to heat 1 kg. of the body through 1° C.

Losses by conduction and radiation are calculated from the formulæ[1]:—

$$W = k, F, t;$$

$$\frac{1}{k} = \frac{1}{a_1} + \frac{1}{a_2} + \frac{\delta}{\lambda}$$

where

W = quantity of heat transmitted per hour.

F = surface exposed to heat, in square metres.

t = difference in temperature between two sides of the surfaces.

k = the total coefficient of heat transmitted for the surface F (*i.e.* the quantity of heat transmitted hourly per square metre and a temperature difference of 1°)

a_1 = 8000 × the coefficient of heat transmitted for the inner surface (a_1 = 8000 for water vapour condensing on a simple metallic wall).

a_2 = the same value for the external surface F.

δ = thickness of wall in metres.

λ = the coefficient of conductivity for heat (iron = 24, copper = 65).

Further, if t_1 and t_2 be the temperatures on both sides of the surface F, s the radiation coefficient (rusty iron 3·36, copper 0·16), b the coefficient of contact (b = 6 for moving air), the value of a_2 is determined by the formula:—

$$a_2 = 125s \times \frac{1{\cdot}0077t_1 - 1{\cdot}0077t_2}{t_1 - t_2} + 0{\cdot}55b\,(t_1 - t_2)^{0{\cdot}233}$$

At a temperature of t_1 = 124 (steam) and t_2 = 20 (average temperature of the air surrounding the oven and pipes), according to the above formula:—

$$a_2 = 1{\cdot}7092s + 1{\cdot}5194b$$

Therefore, for cast iron

$$(s = 3{\cdot}36;\ b = 6)\ a_2 = 15{\cdot}038$$

and for copper

$$(s = 0{\cdot}16,\ b = 6)\ a_2 = 9{\cdot}5675.$$

For the purposes of calculation, the conduction and radiation of the four steam pipes (entrance and exhaust), the copper connecting pipes, the condenser head with connecting pipes, and the surface of the oven cover must be taken into consideration.

3. *Four Steam Columns.*—Their dimensions are: diameter D = 0·247 metres, thickness of wall δ = 0·020 metre, and length l = 7·4 metres. Therefore F = D . πl = 6·44 sq. metres. Now, since λ = 24, a_1 = 8000, a_2 = 15·04, the coefficient of transference of heat k in this case works out

[1] Taschenbuch, *Hutte*, 16th edition, vol. I. p. 306 *et seq.*

as 14·826, and the heat transmitted from each column $w = 9927{\cdot}25$ cals. The amount of heat lost from the four columns, therefore, amounts to

$$Q_3 = 39{,}717 \text{ cals.}$$

4. *Copper Connecting Pipes (Bent Tubes).* — $D = 0{\cdot}030$ metre, $\delta = 0{\cdot}003$ metre, free length $l = 0{\cdot}270$ metre, and number $= 200$. The total surface $F = 200 \times 0{\cdot}030 \times \pi \times 0{\cdot}270 = 5{\cdot}089$ sq. metres. According to the above formulæ, $\alpha_1 = 800$, $\alpha_2 = 9{\cdot}57$, $\lambda = 65$, the coefficient $k = 9{\cdot}554$, and the heat lost

$$Q_4 = 5057 \text{ cals.}$$

5. *Condenser Head and Connecting Pipes.* —The total free length of the connecting pipes not bricked in was $l = 4{\cdot}24$ metres, $D = 0{\cdot}048$ metres, so that $F = 0{\cdot}6394$ square metres. With δ equal to $0{\cdot}003$ metre we got from the formula $k = 14{\cdot}98$ and $q_1 = 996$ cals. The condenser head has a surface of $F = 1{\cdot}227$ square metres. Since $\delta = 0{\cdot}020$ metre, and as in 3, $k = 14{\cdot}826$, $q_2 = 1891$ cals. The total loss of heat therefore amounts to:—

$$Q_5 = 2887 \text{ cals.}$$

6. *Surface of the Oven Jacket.* —The tables are 56 mm. high, its upper plate is 7 mm., and its lower plate 6 mm. thick. Since the total height of the oven amounts to 6·4 metres, there remains a space of $6{\cdot}4 - 1{\cdot}4 = 5{\cdot}0$ metres of free space between the tables which is surrounded by iron plates 2 mm. in thickness.

The twenty-three heated tables are impinged with steam in their interiors for a height of $56 - 13 = 43$ mm.

Therefore that surface of the oven jacket from which heat radiates to the atmosphere is $F = 23 \times 5 \times \pi \times 0{\cdot}043$ metre in area. If the thickness of the table wall at its outer circumference be taken as 40 mm., we have as in 3, $k = 14{\cdot}65$, and the hourly transference of heat $W = k \cdot Ft = 14{\cdot}65 \times 15{\cdot}54 \times 104 = 23{,}670$ cals.

The interior surface of the cover impinged by the warm air of the oven is $F = 5 \times \pi \times 5 = 78{\cdot}54$ sq. metres in area. Inside, the air is at 57°, but outside it is at 20°. In this case $\alpha_1 = \alpha_2 = \alpha$ must be substituted, and we get

$$\alpha = 125 s \frac{1{\cdot}0077^{57} - 1{\cdot}0077^{20}}{37} + 0{\cdot}55 \times b \times 37^{0{\cdot}233}$$

when $b = 6$, $s = 3{\cdot}36$, then $\alpha = 11{\cdot}72$.

Consequently, with a plate thickness of 0·002 m

$$\frac{1}{k} = \frac{2}{\alpha} + \frac{\cdot 002}{24} \quad \therefore \; k = 5{\cdot}857.$$

The hourly transference of heat from the air at 57° to the air at 20° through the oven jacket is therefore $q_2 = 17{\cdot}020$ cals. Consequently, there passes through the oven jacket, as a result of conduction and radiation,

$$Q_0 = 40{,}690 \text{ cals.}$$

SUMMARY.

Heat Balance of the Oven.	Cals.	Per cent.
A. Used for drying the coals	1,291,105	77·07
B. Heat lost by :—		
1. Heating the coal	28,533	1·71
2. ,, ,, drying and waste air .	266,979	15·94
3. Radiation from the steam columns . .	39,717	2·38
4. ,, ,, ,, copper connecting pipes .	5,057	0·30
5. ,, ,, ,, condenser head . .	2,887	0·17
6. ,, ,, ,, oven jacket . .	40,690	2·43
Total heat required per hour .	1,674,968	100·00

C. Passage of Heat through the Table Plates.

From the twenty-three heated under plates of the tables, 6 mm. in thickness, with a total surface $F = 379{\cdot}35$ sq. metres and a coefficient of heat transmission[1] $k = 14{\cdot}69$, a total of 373,327 cals. is emitted, the greatest part of which is utilised in heating the atmosphere. In the interior of the oven a total of 1,586,617 cals. is required for heating and drying the coal and for heating the air. Of this, the above 373,327 cals. are obtained from the lower surfaces of the tables, so that 1,213,290 cals. must still be supplied by the upper surfaces of the tables. Therefore the coefficient of heat transmission for the upper side of the table from the steam to the coal through an iron plate 7 mm. thick amounts on the average to

$$k = \frac{W}{Ft} = \frac{1{,}213{,}290}{379{\cdot}35 \times 67} = 47{\cdot}71,$$

a value which is about three times the value of that from steam to air. For the moist coal on the upper table it will be higher, and lower for the dry coal on the lower tables.

D. Steam Requirements of the Oven.

Calculated from total heat required per hour as determined above, and the heat of evaporation of the applied steam at 2·3 atms., absolute pressure is

$$Q = \frac{1{,}674{,}968}{519{\cdot}428} = 3223 \text{ kg.}$$

[1] When $t_1 = 124°$ and $t_2 = 57°$, $a_2 = 14{\cdot}774$.

If only the internal heat of evaporation is taken into account (compare p. 363), we get:—

$$Q = \frac{1,674,968}{477 \cdot 4} = 3509 \text{ kg.}$$

Further reference to Randhahn's calculation of the useful effect and the representation of the balance of heat in the whole briquetting plant will be given later in Section XI.

II. The Drying Process in the Steam Table Oven.

In order to closely define the process of drying, Randhahn took samples of coal from every table in six ovens simultaneously and determined the content of water in the samples. From this he calculated the amount of water lost from table to table by each 100 kg. of the crude coal supplied The calculations and a diagrammatic representation [1] gave the following main results:—

1. The largest quantities of water were given up above the sieve table, which was situated very low in the whole of the six ovens, being between the 14th and 15th steam tables. The average losses of water were—

On the Heated Tables.	1 to 14.	15 to 23.	1 to 23.
	kg.	kg	kg
Per each 100 kg. crude coal . .	2·6	1·4	2·1
In absolute quantities per hour .	115·7	62·3	92·3

2. Accordingly, the sieve and roll tables put back the drying by two to three tables, due principally to the fact that the doors of the sieve table are left open, the coal absorbing moisture from the incoming air, in addition to cooling down. The deleterious effect of the sieve table increases as the moisture content of the coal fed on to it decreases, *i.e.* its effect becomes worse as it is situated lower in the oven and as the drying of the oven becomes more and more efficient.

3. On the cooling tables (here the 24th and 25th) and on the way to the press stores the coal always reabsorbs water. A total of 111·4 kg. of water is volatilised unnecessarily, *i.e.* a total of $5\frac{1}{4}$ per cent., assuming an evaporation of 2124 kg. per hour.

Consequently, the sieve and roll table should have a higher situation, as is already carried into effect at many works using steam table ovens (see p. 386); further, the doors of the sieve table should be kept

[1] *Z. Braunkohle*, 1907, vi., No. 24, pp. 421–422.

closed as much as possible. A compact arrangement of cooling tables and conveying appliances prevents the losses of heat in drying, but hinders the cooling of the dried coal which is so essential to the pressing of good briquettes.

III. Randhahn's Proposals for improving Steam Table Ovens.

It is obvious from the above heat balance-sheet that by far the greatest proportion of the heat (77·07 per cent.) led into the oven is utilised in drying the coal, and without further ado it may be said that no economy can be effected in this quantity of heat. On the other hand, it appears highly possible that economies could be effected with regard to the losses of heat. In order to prevent the radiation from the steam columns and the connecting bends (2·68 per cent.) from the edges of the steam-heated tables, which give up 23,670 cals. per hour (p. 397 (6)), representing 1·41 per cent. of the total heat required, and to prevent, as adequately as possible, the coal absorbing moisture from and being cooled by the air, Randhahn proposes to surround the oven with a special jacket and to regulate the air-supply.[1]

A free annular intermediate space 5 to 10 cm. wide should be left between the oven and the jacket, which must enclose the four columns with the connecting bends and be attached by means of brackets to the columns or to every third or fourth table. It must be provided with doors in the usual way, but these must only be opened for the purposes of control, renewals, or some similar object. The bends require specially tall accessible doors. The air required is drawn from just under the roof of the drying room—where the temperature is some 10° or 15° higher than that near the floor—by means of iron pipes provided with adjustable slides for regulating the supply, and introduced first into the annular space, from whence it passes to the lower portions of the oven. By means of coverings for the annular space attached to certain tables, alternating with circular coverings, built in two sections, for the hole in the centre of other tables, combined with side openings from the cover to the exhaust flue, the circulating air can be led on the counter-current principle in a rising zigzag path from the outside to the inside of one table, and from the inside to the outside of the next over a certain number of tables, and finally led away to the flue. In this way the quantity of air should be cut down to the lowest possible theoretical amount. The drying operations should become regular and continuous, and the output of the oven should be favourably affected,

[1] *Z. Braunkohle*, 1907, vi., pp. 423–424, figs. 231–233.

especially when the air is preheated. According to Randhahn, the economy in steam obtained by the application of a jacket and regulated air-supply as established by calculation should total:—

(a)	By diminution of the radiation losses .	4·1 per cent.
(b)	By drawing the air from the roof of the drying room	5·0 " "
(c)	By removing the influence of the sieve table	2·5 " "
	Total	11·6 per cent.
	By preheating the air supply .	10·0 " "
	Grand total	21·6 per cent.

With regard to the practical utility of Randhahn's proposals, experienced briquette-factory managers who consider the existing steam table driers capable of improvement are afraid that their execution would favour the outbreak of fires in the ovens and would increase the difficulties of extinction. Whether and to what extent these considerations are justifiable can only be decided on the basis of practical experiments, and it is highly desirable that such should be undertaken. If it is possible, on the grounds of safety or from other causes, to bring only a part of the Randhahn system to application on a working scale, not inconsiderable advantages and economies would undoubtedly be obtained.

A close approach is the jacketing of the steam columns and the bent connections, which has been carried out for several years by the Konigin Marienhütte at Cainsdorf i. S., and which appears to require no further thought if a deposition of coal dust on the bent pipes is really prevented by the method of working. If this is not the case, the jacketing may become disadvantageous, inasmuch as the quantities of dust deposited on the hot bends will rapidly become overheated and ignite easily. The possibility of inspection is removed, control made difficult, and the removal of dust made complicated, whereby the dangers of fire are increased

F. W. Foos[1] has endeavoured to increase the heating effect of a steam table by causing the steam circulating in a sector to pass rapidly in several radial, concentric, or any predetermined directions through the steam space before it leaves the table as condensed water or waste steam. This is done by a suitable number of division walls also acting as stiffeners for the table plates. By this means it is obvious that a more complete distribution and utilisation of the heating steam is attained than in the earlier general design. There seems a doubt, however, as to whether an undisturbed removal of the condensed water

[1] *Z. Braunkohle*, 1907, vi., No. 8, pp. 132–133, fig. 75.

26

could take place under these conditions, and it still remains to be seen how such an arrangement would behave in actual practice.

Further information as to the suitability and capability of the steam table drier as compared with the steam drum tube drier will be given at the conclusion of the following description.

The Steam Drum Tube Drier (figs. 150 to 156).—This tube drier, invented by R. A. Schulz, a civil engineer of Halle, and, during the operation of the patent, built exclusively by the Maschinenfabrik

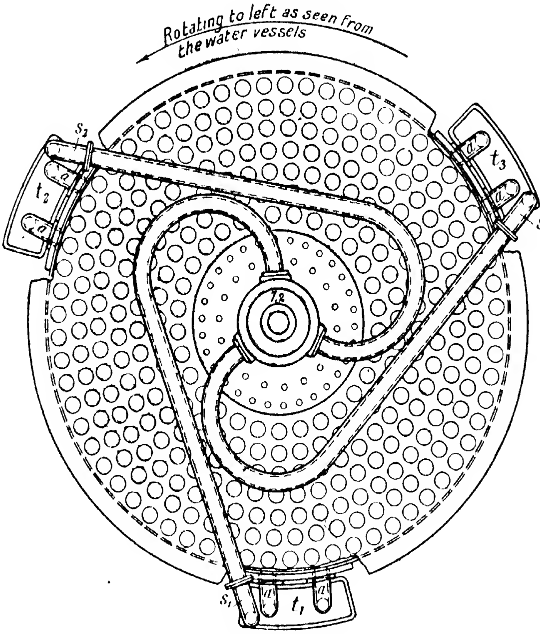


FIG. 150.—Buckau tube drier. Lower end plate.

Buckau of Magdeburg-Buckau, resulting in its being called the Schulz or Buckau tube apparatus, was first installed at the Rodder pit at Brühl[1] in the middle of 1880, and up to the present time has been produced in such large numbers that even now it is to be met with almost as frequently as the steam table drier (see p. 376).

After the expiration of the patent, tube driers were built by other engineering firms producing machines for briquette factories (Zeitzer Eisengieszerei und Maschinenbau-Aktiengesellschaft, Zeitz; the Konigin Marienhutte, Cainsdorf i. S., and so on), in addition to the Buckau Maschinenfabrik already mentioned.

[1] *Z. f. B.-, H.- und Sal-Wesen i. Pr. St.*, 1888, pp. 249-250 and table vii., figs. 15 to 18.

The steam drum tube drier consists essentially of a long inclined cylindrical drum (fig. 152) built up of boiler-plate shell rings riveted together and provided internally with a wide, flue-shaped axle tube A, perforated along its whole length with a large number of holes and a large number of narrow, welded, drying tubes *r* arranged in concentric series. By means of a worm wheel rim K on the front end plate the drum is slowly revolved continuously with the aid of the driving worm S. Moist coal passes from the coal-cellar over the alternating inclined plates in the charging shaft F into the real charging space, where it is distributed by a supply slide into the open upper mouths of

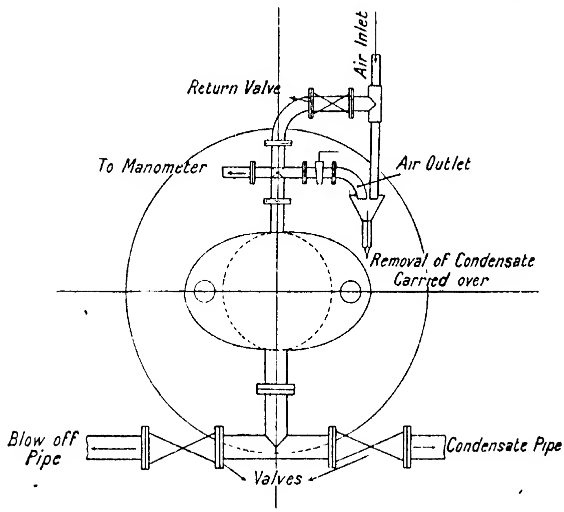


FIG. 151.—Scheme of the piping in front of the lower revolving pin of a tube drier.

the tubes *r*, and as a result of the inclination and revolution of the drum it slides, rolls, or trickles through the tubes. At the same time hot steam (usually waste steam) enters the hollow axle A through the upper hollow cast-steel revolving pin Z_1, streams through the openings *o* on all sides into the surrounding space, circulates round the tubes *r*, and becomes condensed to a very large extent by heating them up. The dried coal ultimately falls from the open lower ends of the tubes into the trough of a worm conveyor, while the condensed water collects on the bottom of the drum and is removed during the revolution through the draining branches *a a* (figs. 150 and 152) into the water tanks t_1, t_2, or t_3, and thence into one or the other of three coiled copper pipes s_1, s_2, s_3, which convey the condensed water with a portion of the waste steam into the lower hollow cast-steel revolving pin Z_2. From

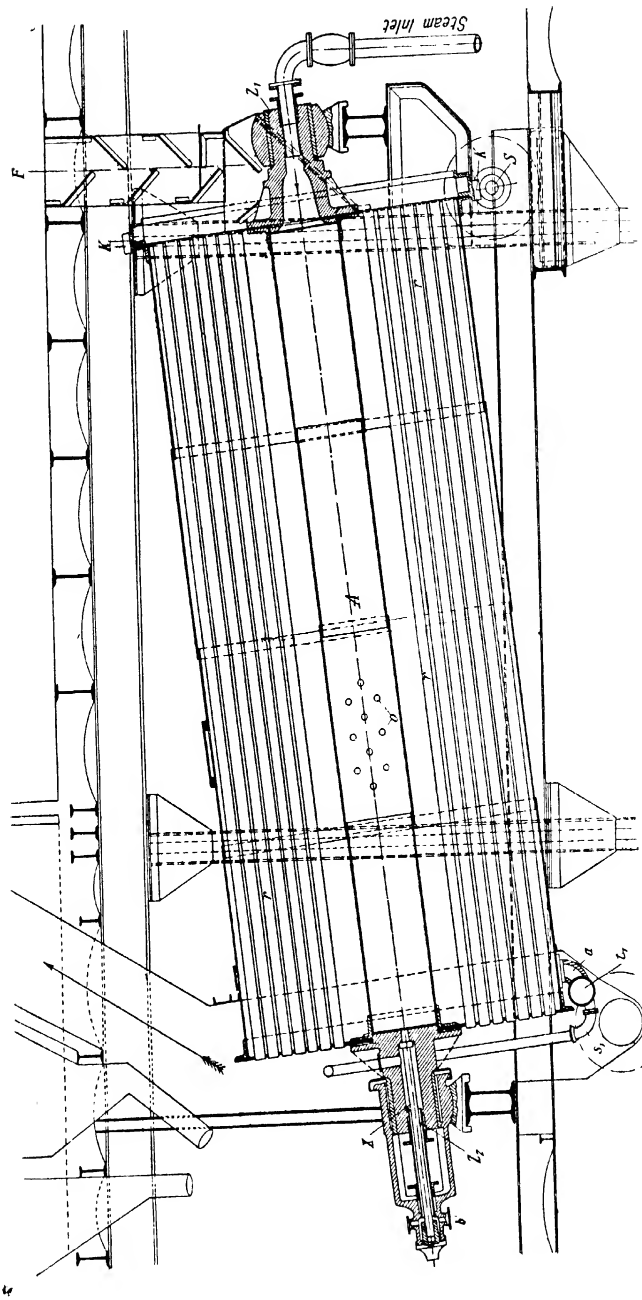


FIG. 152.—Buckau steam drum tube drier. Section.

the axle tube the mixture proceeds through a branch *b* connected to a pipe usually leading to a condenser head. The axle tube is made steam tight by two readily accessible stuffing boxes.

In recent times the lower portion of the tube drier is so arranged that it is situated completely outside the dust chamber connected to the discharge side of the drier. This is a result of the mine inspection orders[1] for the prevention of coal-dust explosions.

The steam pressure to be maintained in the tube driers is, in general, as high as that in the steam table ovens, but in the driers working on the counter-current system it rises to upwards of 3 atms. super-pressure. In order to read off the steam pressure, a manometer is attached to a side branch pipe at the top of the front plate as shown in fig. 151.

The remaining piping which is now often met with in front of the lower revolving pin at many works, such as, for example, the Emanuel-grube at Naudorf, Lower Lausitz, and the accessories are also represented diagrammatically.

During ordinary working only the one at the right of the two valves in the pipe at the bottom is left open, in order to allow the condensed water to pass into the condenser pipe along with the residual steam. The left valve, however, is only opened after closing the one at the right, when the drier is to be put out of operation and the contained steam has to be removed into the open as rapidly as possible through the exhaust pipe. Obviously it is necessary to previously shut off the steam inlet valve below the upper revolving pin Z_1 (fig 152). As a result of these measures a very rapid diminution of pressure takes place in the steam space of the drum, and as soon as the pressure falls below atmospheric the recoil valve shown at the right above the upper branch pipe in fig. 151 opens automatically; air streams in until it finally completely fills the space.

When the drier has to be put into operation again the exhaust valve is first closed, the tap opened in the air exhaust pipe, and then the steam inlet valve in the pin Z_1 is turned on. The incoming steam displaces the air from the upper to the lower end plate of the drum, the return valve again closes, and the air blows through the pipe bent downwards, when a certain amount of condensate resulting from the cooling of the steam is carried off and flows away through the funnel tube. After complete removal of the air the tap is turned off and the valve to the condenser pipe at the bottom opened, whereupon the

[1] *Hallesche Bergpolizeiverordnung*, vom Dec. 21, 1903, § 5, No. 4, section 2.

ordinary working of the drier begins afresh. The whole appliance has proved quite satisfactory in operation.

If such an air-removal appliance is not provided, a certain quantity of air, probably introduced by small leakages during working, remains behind without being displaced into the condensing pipe by the incoming air. Since this air is lighter than the steam, it collects at the upper end plate and during the revolution of the drum always forms the top layer of the steam space. Under certain circumstances this appears to be disadvantageous to the upper ends of the tubes concerned; at least the striking experiences at many works using tube driers have shown that all the upper ends of the tubes for a length of about ½ metre become eaten away relatively quickly and become leaky. Among other things, the eroded portion becomes filled with a resinous mass which can only originate from the lubricating oil deposited there from the waste steam. In this case the dangers are to be traced at least partially to the oil present, a proof of the necessity for an effective separation of the oil from the waste steam (see p. 367).

Principal Dimensions, Speed of Rotation, Number of Tubes.—Heating surface, power requirements, and output of the various manufactured sizes of tube driers are shown clearly in the following table:—

No.	Drum.					Central Steam Tube.	Drying Tubes.			Heating Surface		Power required.	Daily Ou- put (pe 24 hour
	Length.	Diameter.	Thickness of Wall.	Angle of Inclination.	No. of Revs. per min.	Diameter.	No.	Diameter.	Thickness of Wall.	In each Tube.	In the whole of the Tubes.		Dried Coal for Briquettes.
	m.	m.	m.			mm.		mm.	mm.	sq. m.	sq. m.	H.P.	tons.
1	6·4	2·2		5°	4		242	95		1·79	about 430		about 4
2	8	3·5	10	to	to	about	322	95	2½	2·38	,, 765	5	,, 5
3	7	2·4	to	6°	6	40	343	90	to	1·98	,, 680	to	60 to
4	7	2·92	12	seldom	seldom		343	95	3	2·08	,, 715	8	upwar
5	7	2·92		7°	8·5		364–66	95		2·08	,, 755–60		of 70

The tube driers dealt with in the table under Nos. 1 and 2 are older types of lower capacities with regard to the quantities of coal dried. No. 2 proved to be unnecessarily long and cumbersome. Nos. 3 to 5, however, represent newer and latest equipments of the proved best proportions, and whose outputs are increased to such an extent that one drier, like one of the modern steam table driers, is able to provide the whole of dry coal for a modern briquette press even of the heavy or heaviest construction.

The bearings of the two revolving pins (fig. 152) are rounded, and rest in corresponding rounded steps resting on two vertical cross I beams standing close together. Of these the upper ones are supported on strong bracket beams laid in the direction of the drum, while the lower ones rest immediately on the longitudinal girders.

Conveyance of the Coal to the Charging Shaft.—The charging shafts F obtain the moist coal through openings in the coal store. The holes are only a short distance from the neighbouring longitudinal wall of the building, and are made at least 600 to 800 mm. in length of side, and are consequently wide enough to permit of a man passing through them comfortably. Therefore there exists the danger that the workers employed in the coal store to assist the coal towards the openings with shovels or bars, and more especially to break up the stationary coal hoppers (see pp. 343 to 345), may approach too near to one of the openings and suddenly slide into the charging shaft along with the coal and in certain cases may even be overwhelmed with the falling coal. As a matter of fact, accidents of this character have happened repeatedly, sometimes attended with fatal results.[1]

For protection against this chains have been hung into the openings or round iron bars attached at the four corners so that the workers can catch hold of them in case of need. These measures, however, do not always provide complete security, and it would be more effective to surround the openings with a fencework of bars standing only about 30 cm. apart and extending upwards to the foot-bridge. This, however, results in a considerable falling off in the automatic sliding of the coal and an increase in the labour required. The best arrangement is to effect the breaking up of the coal heaps by means of long-handled scrapers from a strong scaffolding, or most simply from the foot-bridge of the band conveyors (see p. 343). If the coal store is high, a second foot-bridge must be provided at a suitable distance below the main bridge, and many briquette factories have recently equipped their coal stores in this way.

Mechanical Coal-collecting Appliances and the like have for their object the regular supply of the coal to the store openings in such a way as to dispense with hand labour. The use of a framework and a trailing chain[2] and other methods have been suggested and in

[1] S. Gertner, "Points concerning the Coal Stores of the Steam Drying Apparatus of the Brown-coal Briquette Factories of the Rhine District, and on the Sources of Danger observed in the Same," *Z. Braunkohle*, 1903, ii., No. 20, p. 257 *et seq.*

[2] *Z. Braunkohle*, 1907, vi., No. 23, p. 379 *et seq.*, figs. 214 *a* to *c*.

some cases tested practically, but in no case have they proved very successful.

Supply Arrangements.—With the tube driers the difficulty has always been that the conveying slide fixed close under the charging hopper F can never be fixed so close to the upper end plate of the revolving drum that small particles of coal cannot trickle through. Further, a portion of the coal taken up by the charged tubes can always fall out again as a result of the slight inclination of the drum. An endeavour has been made to obviate these inconveniences by the following appliances:—

The crown wheel K contains on its inner side a deep ⊔-shaped

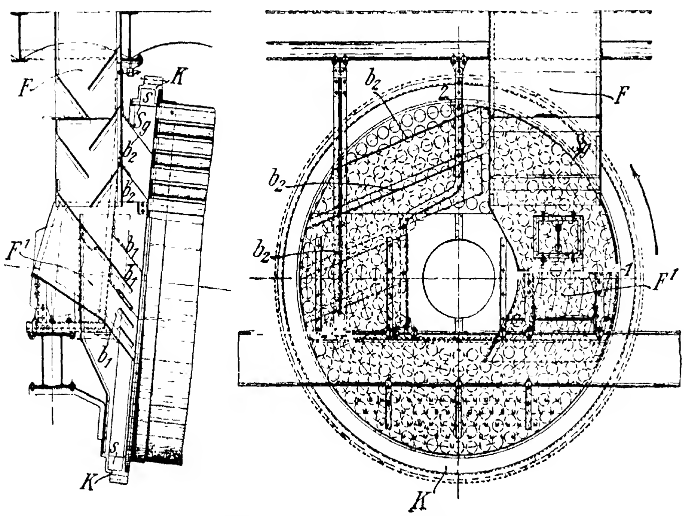


Fig. 153.—Hickethier's supply arrangement for tube driers.

section (figs. 152 and 153), and is divided by means of a large number of cross stays or shovels into cells which catch the coal trickling from the slide and falling from the mouths of the tubes, lift it up during the revolution of the drum, and shoot it back again on to the slide. In addition the so-called impact grids are provided. They consist of a number (corresponding to the number of concentric series of tubes) of quadrant-shaped strips of sheet iron bent in the direction of their radii and connected together by means of cross bands. The grid so formed is supported so as to revolve at right angles to the axis of the drum by means of inclined supporting and hinged bands on the cross beams of the upper rounded pin, and the bent sheet-iron strips lie against the upper end plate of the drum, about their common axis of

rotation, by virtue of their own weight, and keep the mouths of the freshly filled tubes closed from the slide on their lower or inner halves during a quarter of a revolution. It was necessary to leave half the tube open in order to leave enough space for the inevitable circulation of air through the drying tubes. This had the disadvantage, however, that fairly considerable quantities of coal still fell from the open halves of the tubes, and even if these were taken up by the cells in the crown wheel and redelivered, the real object of the impact grid was attained only very incompletely, especially when the sheet-iron strips no longer lay close up to the drum, as a result of wear or other causes.

The Hickethier patent supply arrangement introduced several years ago shows considerable progress over the above.

From the coal store the coal slides and sinks through the usual charging hopper F (as in fig. 152) into the real charging space F_1, in which inclined slides b_1 are fixed. These slides convey the coal in a loose form to the individual tubes and effect an excellent charging of the series of tubes The coal trickling between the slides and the end plate of the drum is taken up, as previously described, by the ⊔-shaped worm crown wheel provided with shovels s, is lifted up, but then falls on the segment S extending from 1 to 2 into the so-called "after-charging space" F_2 whose inclined plates b_2, arranged Venetian-blind fashion, supply the coal into the drum tubes. In addition, the coal falling from the previously filled tubes is also caught by these plates and recharged and the 45° inclination to the left prevents excessive charging of the central tubes. The advantages of this arrangement consist principally in a better charging of the tube with a resulting more uniform drying of the coal and a greater output of the drier. The substitution of such an appliance for the impact grid resulted in an increase in output of from 8 to 10 and even 12 per cent.

The Hickethier charging arrangement is constructed by the Eisengieszerei and is already in use in connection with many tube driers, among others at the large briquette works of the Ilse Bergbau Ges. at the Ilse mine in Lower Lausitz.

OTHER SUPPLY ARRANGEMENTS.

In order to prevent irregularities in the supply caused by the adherence of moist, sticky coal in the charging shaft, the Comte Furstenberg Co. of Frechen, near Cologne, use an arrangement protected by them consisting of a swinging slide[1] moved to and fro by

[1] *Z. Braunkohle*, 1902, I., No. 28, p. 342, fig. 136.

means of a cranked shaft below driven from the worm wheel shaft by a belt In this way the coal received on the shaking slide, regulated in quantity by means of a slide, is shaken on to an oppositely inclined distributing plate from which it falls on to the charging slides for introduction into the tubes.

At the Liblar briquette factory at Cologne the same object is attained by arranging a simple feeding[1] roll in the charging shaft just in front of the mouths of the tubes. The roll takes up the pressure of the coal for its own rotation and operation.

Stoppage of the mouths of the tubes and the fall of coal from them is effectively prevented by a coal distribution[2] operated by compressed air, invented by Victor Rolff of Cologne-Lindenthal, and first used at the Wachtberg pit in Frechen. A tube fastened to the charging hopper in front of the drying tubes is provided, on the drum side, with as many holes or small funnels as there are concentric series of tubes. Compressed air is blown through the pipe and its openings into the drying tubes as they come into position, and upsets the little coal heaps lying in the mouths, blowing them, along with the incoming fresh coal, further into the tubes. Several blowing pipes can be applied instead of the single one. At the Lauchhammer briquette factory the output of the drier has been increased by 15 to 20 per cent without increasing the steam pressure.

Motion of the Coal through the Drying Tubes. Turning or Disturbing Ledges. Distributor Bridges.—In the earlier completely open drying tubes the motion of the coal as a result of the inclination and rotation of the drum proceeded irregularly, so that the small coal only rolled slowly along the inner heating surface, while the larger granules rolled on the top of the fine material and passed through the tubes at a greater rate. Under these conditions uniform drying could not be attained, and it was only possible to remove these disadvantages by the introduction of the turning and disturbing ledges[3] which have now become almost universal.

In the equipment usually applied at the present time the turning ledges consist of bands of iron 15 to 20 mm. in breadth or height laid facing each other along the whole length of the drying tube, and pressed against the wall by means of spring cross stays or half-round tension springs riveted to them. The effect of the ledges is to turn over the

[1] *Z. Braunkohle*, 1903, ii., No. 30, pp. 408–409, figs. 227 and 228.
[2] *Ibid.*, 1906, v., No. 8, pp. 116–117, figs. 55 to 59.
[3] *Z. f. B.- H.- und Sal.-Wesen*, 1900, p. 367.

coal and thoroughly mix it twice during each revolution of the drum, so that the whole of its particles come into contact with the heating surface of the tubes and the circulating air approximately uniformly and for equal times, and as a result the drying is carried out much quicker and better than in tubes without ledges. At several works their introduction has increased the output of briquetting coal by about 20 per cent.

The turning ledges with half-round tension springs pressing them against the walls of the tubes are preferable to the cross stays, since they leave the centre of the tube open. With the cross stays the particles of coal, lignite, or basty particles which have balled up in the charging hopper become arrested in their progress and occasionally give rise to stoppages and fires in the tubes.

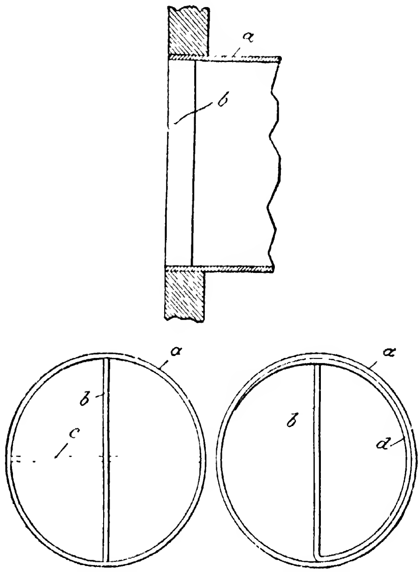


FIG. 154.—Inserted division stay for drying tubes.

This disadvantage should be removed by the distributing stays patented by the brown-coal factory of F. C. Th. Heye of Annahütte, Lower Lausitz,[1] and illustrated in fig. 154 (in longitudinal section above and end view below). In the entrance to the drying tube *a* is fixed a stay *b* which divides any coal balls from the distributing hopper in such a manner that only coal of correspondingly small circumference can enter the tube. In the front view to the left a second dotted stay *c* is seen crossing the stay *b*, while in the view on the right the stay *b* is provided with a circular spring for holding it in position.

At many works spiral iron ledges are clamped in the drying tubes after the Brandt and Fude[2] patent, or in the Zeitzer Eisengieszerei's design, which is provided with approximately eight turns.

Using turning ledges, the time of passage of the coal amounts to

[1] *Z. Braunkohle*, 1903, ii., No. 17, p. 224, figs. 128 to 130.
[2] *Ibid.*, 1902, i., No. 41, p. 492.

25 to 30 minutes, during which period a moisture content of about 50 to 60 per cent. is reduced to about 15 per cent.

Discharge of the dried coal is effected by simple fall from the lower mouths of the tubes into the trough of the common worm conveyor (figs. 155 and 157), which runs along the front of the whole series of tube driers. In order to diminish the unavoidable development of dust during the falling of the coal as much as possible, the mouths of the tubes are provided almost universally with the so-called discharge covers. These are of such form and are so fitted that each drying tube can only discharge its contents when it takes up its lowest position during the rotation of the drum, since this gives the shortest fall. The covers are dealt with more fully in Section VII., dealing with the separation of dust.

Circulation of air and vapour through the drying tubes is generally effected on the parallel-current principle, and takes place therefore in the direction of motion of the coal, so that the vapour escapes from the lower ends of the tubes, where it rises as a result of its temperature and the suction action of the stack, and follows the path shown in fig. 155.

At a number of works, however, the counter-current principle is in operation on the grounds of a simple and complete dust extraction from the vapours, but this will also be dealt with more fully in Section VII.

The drive of the tube drier or of the worm turning the crown wheel is effected, as in the case of the stirring shaft of a steam table drier, either from a common transmission shaft and an engine or by means of a single motor, more especially an electric motor, such as, for example, at the Lauchhammer briquette factory, shown in fig. 155. The motors are arranged in a common narrow room below the charging end plate and the worm drive of the tube drier, the drive being effected by means of a counter-shaft and belt transmission (further information in Section IX.).

With regard to the position of the tube driers, the same holds as for the steam table ovens (p. 392). In the Buckau system of a briquette factory arranged as shown in fig. 128 the tube driers are arranged on the ground floor behind the presses situated in a fore building, while in the Lauchhammer briquette factory shown in fig. 155, as well as in many other works, the tube drier is situated in the upper story of the same building as the presses and the various worm conveyors for the dried briquetting coal.

The latter arrangement renders the installation of the heavy drier more difficult, and in the light of certain mine inspection regulations[1] requires the provision of special bearings as a security against falling.

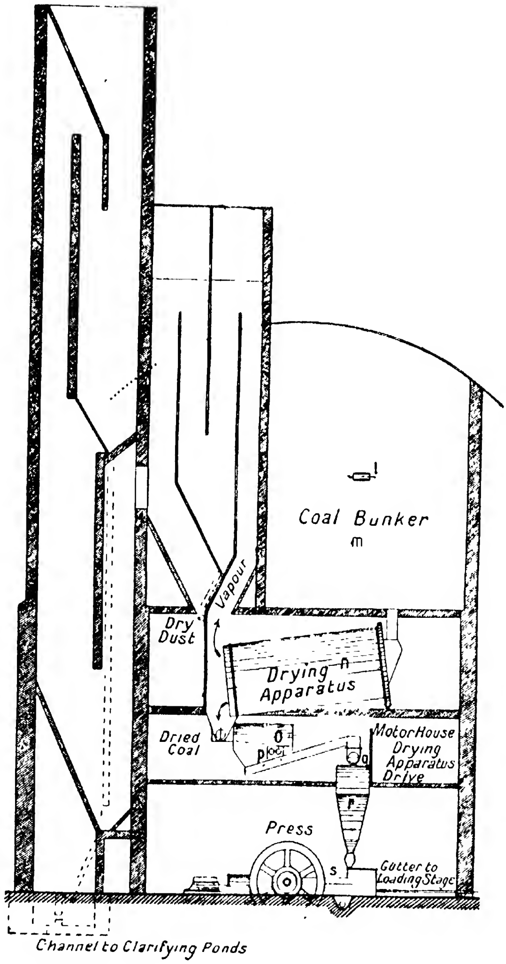


FIG. 155.—Section through the Lauchhammer briquette factory working with tube driers and electric drive.

It provides, however, the advantage that the heating of the air in the press-room by radiation can easily be utilised by taking the necessary warm air through holes in the floor below the inlet end of the drier from whence it is sucked into the drier.

[1] *Hallesche Bergpolizeiverordnung*, vom Dec. 21, 1903, § 11, No. 2.

Recent Proposals for a better Utilisation of the Heat in the Tube Drier.—The Maschinenfabrik Buckau has striven to attain this object by circulating the steam in the drier by means of a steam jet blower[1] in the central tube.

The broad central tube is only connected with the surrounding heating space by means of a number of holes in the two ends. The heating steam entering through the upper hollow end journal first enters, with a velocity of about 30 metres per second, through the narrow central piece of the system of nozzles (on the style of the Korting steam jet blower), and in this way sucks the steam in the heating tube space through the wider nozzle ring and the corresponding holes in the central tube, forces it forward into the closed main portion of the central tube through the holes in the lower end into the heating space, where it is partly condensed and partly returned on the circular journey by the suction effect of the injector system. The steam velocity in the heating tube near the lower end plate amounts to about 1 metre per second, and at the upper end plate to about 0·8 metre per second.

From experiments, the innovation seems to be thoroughly practical and well adapted to give a better heating effect and larger output of the tube driers.

G. Sajatz of Senftenberg[2] proposes to utilise the heat radiated from the drum jacket for the purpose of preheating the moist coal. The jacket is surrounded by drying cells lying in the direction of its length and intercepting the coal fed from above the inlet end plate just in the same way that the inner heating tubes, which here only serve for the finished drying, do.

The drying cells should be built up of external radial ribs on the drum jacket and flanges on both sides, which overlap to a certain extent but leave a suitable free intermediate space. During the rotation of the drum the moist coal is shot through these intermediate spaces and then moves forward alternately over the ribs, jacket, and flange surfaces until it is finally discharged hot through holes in the flange of the lower end plate. Vapours escape through the interspaces of the flanges.

The arrangement, which has not yet reached a trial on a working scale, complicates the simple construction of the tube drier to no small extent, and demands that the coal discharged from the lower end must be returned again to the upper end plate by means of a special arrangement, so that it can proceed to the inner tubes.

It is simpler to surround the ordinary tube drier with heat-insulating material such as is used for steam pipes or cylinders to prevent loss of heat by radiation.

[1] *Z. Braunkohle*, 1908, vii., No. 5, p. 75, fig. 35.
[2] *Ibid.*, 1908, vii., No. 26, pp. 444–445, figs. 226–227.

This has been effected on an experimental scale for several years at the Ilse mine, Lower Lausitz, with several tube driers, the result being that the efficiency (*i.e.* the ratio of the quantity of heat actually used in evaporating water to the real heat applied), usually between 69 and 70 per cent. according to the season of the year, was increased by about 5½ per cent. by insulating the jacket; the output of dried coal remained the same.

Kegel's Tube Drier with Dust Filter and Discharge.[1]—While in the modern steam table ovens the coal dust which has finished drying is sieved, sorted, and led away from the coarser particles early in the drying (see p. 386 *et seq.*, fig. 146), a similar appliance is never provided in tube driers of the ordinary design. C. Kegel has sought

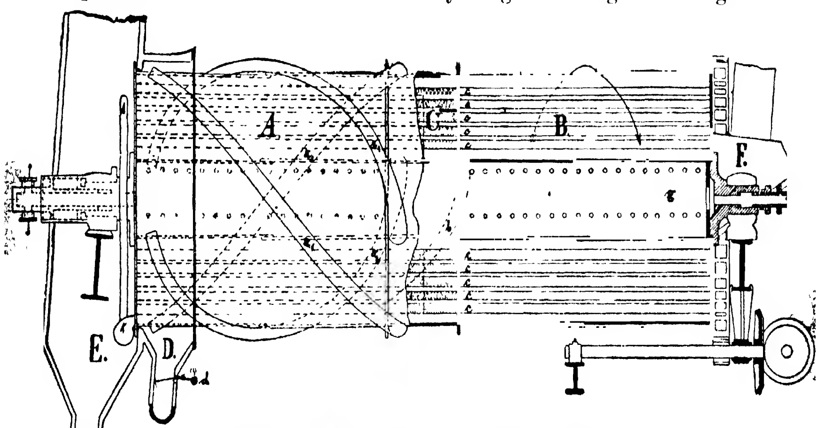


FIG. 156.—Kegel's tube drier with dust filter and discharge.

to remedy this deficiency by introducing a dust-sieving and removal section in the centre of the drier in such a manner as to be steam tight against the heating and drying sections B and A on either side.

In the section C the drying tubes are provided circumferentially with holes which sieve out the fine material from the coal supplied at F coming from the section B (the direction of rotation of the drum being shown by the arrow), while the coarse granules travel into the section A to be further dried and discharged at E in the ordinary way. The dust sieved off is conveyed to the space D in the several steep spiral windings a_1, a_2, a_3, a_4, . . . according to requirements, provided on the outside of the drum, from whence it can be removed to the point of application. In addition, a second sieve section can be provided at the lower end of the drum if required.

The tube *b* acts exactly like the condensed water waste pipes *h* and *k* for the conveyance of the condensed water from B to A. D is closed against the drier, and if necessary provided with a self-closing counter-weight valve *d* so that vapour cannot escape through this part of the apparatus.

[1] *Z. Braunkohle*, 1904, iii., No. 17, p. 229, fig. 126.

Up to the present this commendable invention of Kegel's does not appear to have found application on a practical scale. In case of its introduction with success, coal would certainly be uniformly dried in the tube drier, especially if turning ledges were applied, and the output of dried coal would certainly be increased.

Comparison of the Steam Drum Tube Drier with the Steam Table Drier.

Special attention has already been called to the fact that the ordinary drying systems of the German brown-coal briquetting industry have for a long time consisted almost exclusively of these two types in approximately equal numbers, and at the present time they are introduced in equal numbers although in certain districts one type is preferred while in others the other type finds preference. The choice may not always be made on essential grounds nor on right lines, but the conclusion can be drawn that for working coal of a certain property tube driers are best, and for coals of another nature table driers are best. Further, the two systems may be equal from many points of view, and the special advantages of one are outweighed by the peculiar characteristics of the other.

A hard or sandy coal causes a too rapid wear and tear of the table surfaces and, above all, the plate shovels of the stirrers in the table ovens, and therefore the tube drier is better for this purpose; while a soft damp coal can be worked much more easily in the table drier than in the tube drier, the wear being very considerably diminished.

With regard to the output and amount of steam used, or efficiency, there is not a considerable difference between the two driers. Since the lapse of the patent the price of the tube drier has been considerably lower than that of the table oven (about 23,000 marks against 43,000 marks for the largest-sized driers), and in addition the power consumed (about one-third) and the wages costs are lower in the case of the tube drier. (The labour of the latter, however, always needs extension because of a sieving drum and a subsequent crushing roll whose cost and power consumption must be taken into account.) On the other hand, the general repairs can be effected easily and rapidly in the case of the table driers, and even the occasional extensive repairs are not so difficult and do not take up so much time as in the case of the tube driers, since all the movable parts as well as the sectors of the individual tables are readily accessible and renewable from the outside and—in the

modern choice of the diameter of the opening—are equally accessible from the interior.

In addition, the table driers offer the following special advantages:—

1. The motion of the coal and the course of the drying can be watched at every desired stage (on each table) by inspection and the taking of samples, and can be regulated according to requirements by one or another of the available means, so that the varying moisture and temperature of the coal supplied and of the air introduced, along with the other conditions affecting the drying, may be always taken into account at the right moment.

With tube driers control is only possible at the discharge side, and any required regulation of the conditions always appears too late for the coal already discharged.

2. The coal can be subjected to an after-crushing at a suitable time on the sieve and roll table inside the drier itself.

3. At the same time, the finished dry coal dust can be sieved off and removed at the right time.

This advantage is of course removed with the Kegel tube drier provided with dust-sieving and removal plant.

4. The coal can also be cooled on the last tables in the apparatus itself.

5. In the table ovens there is usually less whirling of the dry dust than in the tube driers (see further information in Section VII.).

These special advantages of the steam table driers are after all so considerable, that in the opinion of many manufacturers, they more than outweigh the disadvantage of high installation and working costs; and this system, which is in many ways still capable of further improvements, is assured of an extended application in the future, particularly for the working up of soft and wet coals.

Combined Use of Table and Tube Driers for the Preliminary and Finished Drying.—At the Robert mine, Wansleben, in the Halle district (A. Riebeck's Montanwerke), such a combination of small tube and table driers has been applied in the new briquette factory erected a few years ago, and is to be seen in the views and description of this factory given below in Section X. The technical disadvantages of both should be prevented, and their advantages brought to the fore as much as possible by such a combination of the two systems. A short tube apparatus about 4 m. long first dries the fresh coal to about 30 per cent. moisture and then passes it on, through a small

intermediate roll-crusher to break up the adhering parts, to a table oven with fourteen tables standing below. The table oven is provided with a sieve table and two cooling tables for sieving away the dust and cooling. Both drying systems are provided with special drive and dust-catchers.

The drying apparatus works well so far as is known, but at all events is more difficult to superintend, and requires more attention to detail than a single system consisting of two large tube or table driers with dust-catchers. In a small factory this unnecessary complication may not have much effect, but in a large factory it would at least become troublesome, and compared with a single drying system would require a larger staff, etc., with resulting increased costs of working. Therefore the example of the Robert mine does not appear to have found any imitators up to the present.

SECTION V.

CARRIAGE, MIXING, COOLING, ACCUMULATION, AND CONVEYANCE OF THE DRIED BRIQUETTE COAL TO THE PRESSES.

In order to produce strong, uniform briquettes (especially domestic briquettes), the dried coals must first be thoroughly mixed in order to equalise the almost unavoidable variations in the moisture content and temperature of the coal delivered from the various driers, and also to ensure thorough incorporation of the different-sized particles.

For this purpose the coal issuing from the tube driers is sieved and afterwards crushed between rollers. At the same time it is essential that a certain amount of cooling (from 60° to 95° C. down to 30° or 40° C., according to the drying system and steam pressure) of the dried coal, which is still too hot, should take place.

During temporary stoppages, such as are occasioned by repairs to presses or driers, it is necessary to be able to fall back on a stock of dry coal in order to maintain a normal working of the plant. The mixing and cooling appliances are often utilised for this purpose.

For the purposes of conveying briquetting coal from the various driers to the sieving and final rolling appliances sometimes provided, to the mixing, cooling, and storage houses, and finally to the charging hoppers of the presses, spiral conveyors are the most suitable and are often used exclusively. They may be horizontal, ascending or descending, always act as mixing arrangements, and often have a cooling action. Elevators (dry elevators) are used for lifting in a vertical direction to a room or apparatus situated on a higher level. Band conveyors suitable for moist coal cannot be adapted to dry hot material because of the reasons already given on p. 341, and especially since they are always completely destroyed in the occasional fires occurring in the sheds, which must of necessity be closed in. At the present time, therefore, band conveyors are never met with in the drying operations.

In the following pages the most important varieties of spiral conveyors will be described and illustrated (figs. 157 to 164).

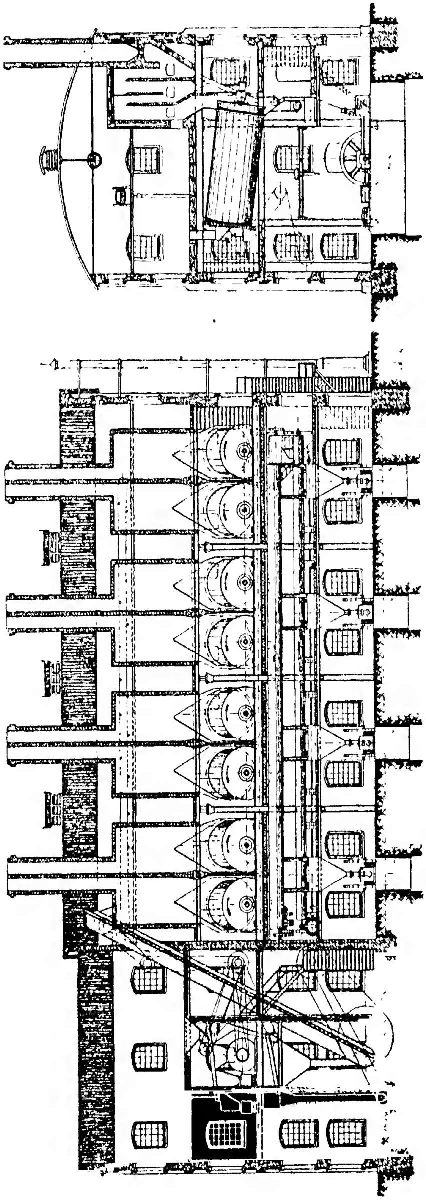


FIG. 157.—Briquette factory with tube driers. Camdorf construction. Longitudinal and cross sections.

Conveying and mixing spirals have already been dealt with in the section on coal briquetting as regards their application to pit coals and pitch, and reproduced in figs. 15, 16, 22, and 27, as well as in the illustrations of complete coal-briquette factories (figs. 87 to 103). Various examples of their application to dried brown coals can be seen from figs. 128, 138, 147, 149, and 155 in the last section.

In fig 128 the dry coal falls from the whole of the tube driers arranged in line, through inclined covered spaces of sheet metal, into the brickwork trough of the oven or store spiral which is connected to an ascending spiral conveyor at its end. This shoots the coal into a conical drum sieve to sort out the coarse grains and lead them to a final roll-crusher. The fine coal and the crushed product are taken up by a second ascending worm conveyor and carried to the horizontal press or distribution spiral situated above the charging hoppers of the presses. (Special mixing

and cooling chambers are still non-existent in this old arrangement of the Buckau system.)

Fig. 138 shows an oven spiral in the bottom of the wedge-shaped collecting and mixing chamber of an old wind-oven installation.

In fig. 147 the oven spiral is situated at the left, and runs under the floor through an iron trough closely covered and connected with the last table of each oven by means of an inclined pipe. In fig. 149, however, the oven spiral is situated to the right, above the floor, in a brickwork worm trough. The cylindrical jacket of the short downcomer from the foremost table drier (still to be installed) can be seen in the front.

Fig. 155 partially shows the same arrangement of spiral conveyors, etc., as in fig. 128, but the first ascending spiral is omitted because of the high situation of the tube drier *n*. From the oven worm the dry coal passes directly into the drum sieve *o*, *p* is the after-crushing roll, *q* the distributing spiral.

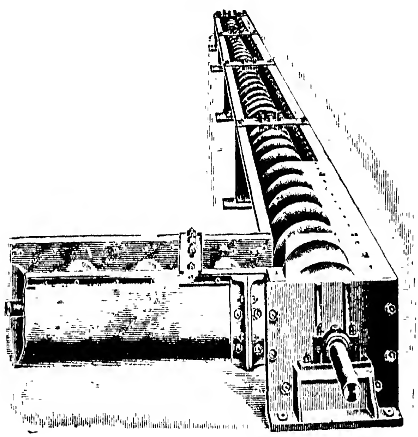


Fig. 158.—Two spiral conveyors joined together at right angles.

Fig. 157 is a longitudinal and cross section through a briquette factory with eight tube driers and four presses (Konigin Marienhutte at Cainsdorf). Among other things it will readily be seen how the dry coal is conveyed through the collecting spiral situated in front of the driers to the drum sieve with roll-crusher at the right, and is distributed to the presses from the press spiral running to the left. In special cases the dry coal can be drawn off from the oven spiral through two downcomers into the charging hoppers of the presses by the shortest way. It is then only necessary to open the slides over the discharge tubes, which are usually kept closed.

In the following pages the various spirals and spiral combinations of approved construction by the G. F. Lieder elevator and spiral conveyor factory in Wurzen, Saxony, are represented. Figs. 158 to 162

illustrate complete screws in which the spirally wound sheet-iron plate is attached directly to the shaft, together with which it fills the

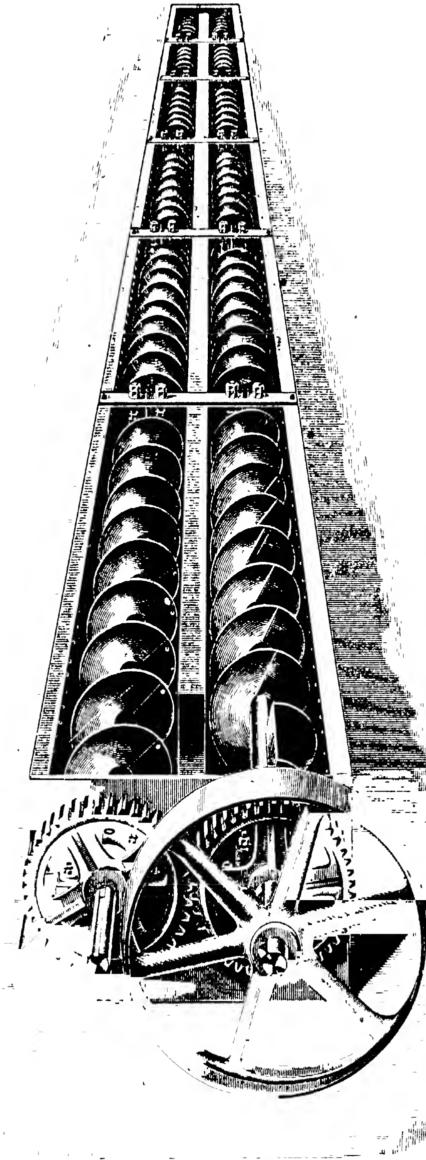


FIG. 159.—Two parallel spiral conveyors (double worms connected together and rotating in opposite directions).

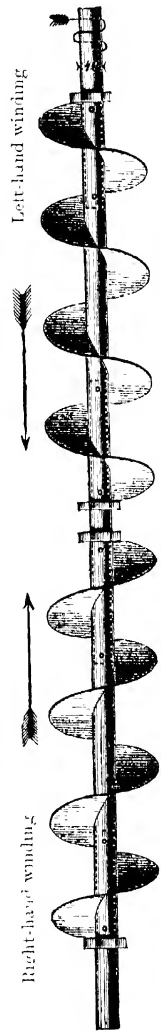


FIG. 160.—Two spiral conveyors on the same shaft conveying to the same point.

whole circular section. At the present time the shafts are invariably round, and consist of perfectly straight iron tubes of sufficient strength;

they have the advantage of lower weight, power consumption, and price for equal life over the four-cornered iron shafts which were formerly applied almost universally and are even now often used. The well-machined driving and bearing journals fixed in the tubes revolve in closed white-metal bearings.

Lignum-vitæ bearings have not proved so good; they wear badly after eight days' use, as a result of which the spirals rub on the trough and soon become ineffective.

Spirals of 300 to 450 mm. diameter and 2 to 3 mm. thickness are usually applied in brown-coal briquette factories. The accessory iron troughs are made of sheet metal stiffened at the upper edges with angle-iron and fitted at each end with a cast-iron head-piece provided with bearings for the shaft. If the length is over 3 metres, they are strengthened by two intermediate bearings which are fastened to cast-iron trough couplings built in two sections. The bearings are provided with dust-tight lubricators and the iron troughs can be covered with iron plates making dust tight joints. For oven spirals and the spirals in the storage and cooling spaces brickwork troughs lined with cement and carefully ground out are fairly often used.

Fig. 158 shows two complete spirals in iron troughs connected with each other at right angles. One spiral acts as a carrier to the other.

In fig. 159 two parallel spirals are driven in opposite directions in an iron trough built in two sections from the same indicated drive by means of a pair of gear wheels.

Fig. 160 illustrates two spirals, one with a left-hand winding and the other with a right-hand winding attached to the same tubular iron shaft. Each spiral carries the material to the centre, whence it is carried away through a discharge opening in the trough (not represented).

Figs. 161 and 162 illustrate an improved coupling for spiral conveyor sections introduced by G. F. Lieder.[1]

Each individual spiral section *a* is provided at both ends with an outstanding pin *b'* which is to be connected with the bearing bolts *b* (fig. 161) on the installation of the spiral conveyor. In this way the bearing pin can be removed at any time and replaced by a new one. Spiral wings *q* can be used with advantage for this combination, then sectional naves being prevented from revolving by means of two screws. In this way a strong coupling of the whole spiral length is effected, and the ineffective space between two neighbour-

[1] *Z. Braunkohle*, 1904, iii., No. 17, pp. 230-231, figs. 88-89.

ing worm sections is limited to the very lowest extent. Further, the installation of the spiral conveyor and the removal of any possible damaged sections is very considerably facilitated.

If it becomes a question of thoroughly mixing the coal rather than conveyance, spiral conveyors are advantageously employed instead of the complete worms. They consist of strips of iron connected to and at definite distances from the tubular iron shaft by means of bolts (fig 163), or of adjustable spiral sections (fig. 164), each of which is

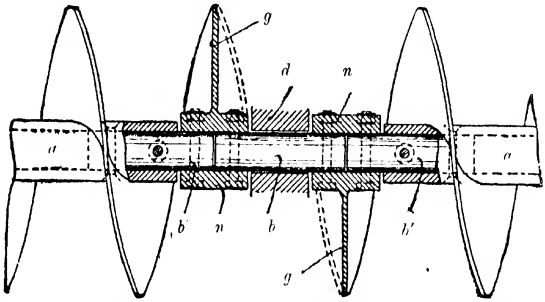


FIG. 161.—Lieder coupling for worm-conveyor sections. Longitudinal section.

fastened to a tubular iron shaft (somewhat stronger than usual) by means of special screwed bolts Such spiral conveyors were formerly very much used for the conveyance of dry brown coal, but since they had a very much smaller output they were very much less satisfactory as conveyors than the ordinary forms

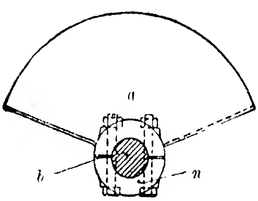


FIG. 162 —Lieder coupling Section.

Elevators for Dry Coal (Dry Elevators) are usually built on exactly the same lines as the elevators for moist crude coals (wet elevators, pp. 339 to 340). They are invariably arranged vertically, and are surrounded by brick walls. At moderately large plants with three wet elevators there is only a single high-capacity dry elevacor, because of the large loss of water during drying.

During the operation of this elevator it is impossible to prevent raising clouds of coal dust which may be very easily ignited, and formerly many of the disastrous fires and explosions had their origin at this point. Recently therefore the mine police of the Halle and other districts have decreed as follows:—

Elevators for dried coal must be placed outside the factory buildings altogether; or, if inside, they must be placed in special spaces so that the

entry of coal dust into the rooms of the factory is prevented.[1] The enclosing walls must be constructed without dead corners, to prevent a permanent deposit

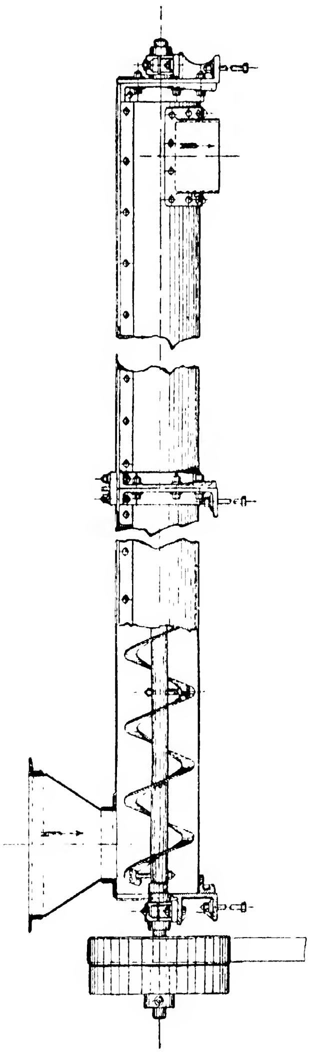


FIG. 163.—Spiral worm (worm mixer) of iron strips.

FIG. 164.—Spiral worm of adjustable sections wound on a specially strong tubular iron shaft.

of coal;[2] they must extend above the factory roof, and their free openings must be protected against the entrance of sparks by suitable arrangements.[3]

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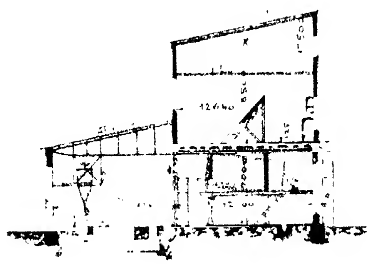
1 *Hallesche Bergpolizeiverordnung*, Dec. 21, 1903, § 4, Nos. 1 and 8.

2 *Ibid.*, § 4, No. 4.

3 *Ibid.*, § 5 and § 6, No. 3.

Elevator, Cooling and Storage Shops.

In modern briquette factories particularly those of the Zeitz system, the dry elevator has been installed in an outbuilding standing by itself or connected with the main building only by narrow intermediate buildings, while cooling and storage shops are arranged one behind the other quite apart from the elevator house. The twelve-



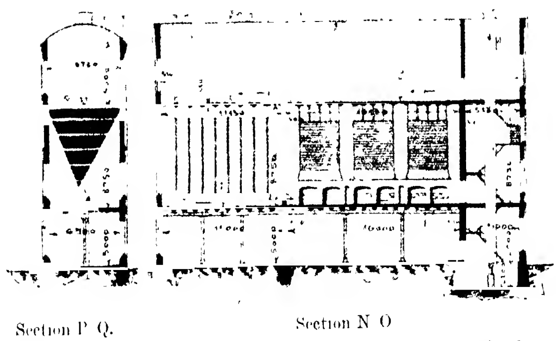


FIG. 165.—Section (L M) through the drying and press houses, longitudinal section (N-O) through the dry elevator, cooling and store houses; and section (P-Q) through the storehouse of a modern Zeitz twelve-press factory.

press factory of Zeitz construction to be described later in Section X. (see plan and section R-S, and sections A-B, C-D, N-O, and P-Q) gives an example of such a system. Fig. 165 shows the elevator house at the right of the longitudinal section N-O, the cooling chamber in the centre, and the storage room to the left, in addition to the various spiral conveyors.

The elevator discharges the dry coal lifted to the upper story of the tall outbuilding into the upper spiral conveyor, whose longitudinal

axis is central with that of the three rooms described above As a rule, this spiral only conveys the coal to the three sections of the cooling room arranged one after the other, into which the coal falls through holes in the bottom of the worm trough. The quantity of coal can be regulated by slides attached to the openings in the trough If, however, more dried coal is supplied than the cooling arrangements (draught appliances, see below) can or should deal with, or if the cooling arrangement must be put out of action either wholly or partially because of some interruption in working, the spiral conveys the excess of coal to storerooms beyond the cooling chamber, where it is drawn off in a similar way

Centrally, below the cooling or storage chamber, a supply spiral operates in the opposite direction in such a way that the coal supplied to it is conveyed to the end of the press spiral situated below. The latter conveys the coal to the press room, and finally distributes it to the tops of the individual presses (fig. 165, left of section L–M)

Cooling Arrangements.

The simplest cooling appliances are the cooling tables already described in connection with the steam table driers (p 380) They consist either of the two or three lowest tables, which are unheated and in some places are hollow and cooled with water, or of special complete discs The coal delivered from the lowest-heated table at a temperature between 65 and 60 C is gradually cooled down to about 50 C. by being turned and dragged over the cooling tables by the shovels of the stirring arms and being subject to the action of fresh air entering the bottom of the apparatus. If a storeroom of ample proportions exists and the dry coal is conveyed to it regularly, this usually suffices for all practical purposes, and good briquettes can be produced, since the coal will be cooled considerably (down to about 30° C.) during the to-and-fro motion in the worm conveyors, storage in the storerooms, and later in the charging hoppers of the presses.

In case of lack of storage space, a combination of cooling tables and several long worm conveyors is employed in order to attain the necessary admixture, equalisation, and cooling by the to-and-fro motion. The result, however, is only satisfactory when the individual driers are working well and delivering dried material which does not differ much as regards water content and temperature.

If it is desired to become more independent of the supervision of the oven attendant and the briquette manager, and also in the interest of

an increased drying effect, the admission of fresh cool air into the drier is prevented as far as possible. Further, it is advisable to carry out the cooling outside the drier and to provide special cooling arrangements.

Such appliances are indispensable at all works using tube driers the usual construction of which does not permit of cooling inside the apparatus. Independent cooling tables and coolers on the principle of the Rowold wind oven are most usually applied. Occasionally, boiler-tube coolers also find application.

Table Cooling Appliances are built on the lines of the Zeitzer steam table driers, but instead of hollow tables are provided with complete discs usually of 3·8 metres diameter. Generally speaking, five such discs and one sieve and roll table are sufficient, but it is obvious that the latter need only be provided when the drying has been carried out in tube driers. In this way the installation of a special drum sieve with after-crushing roll, which otherwise must be provided as previously described, is obviated. Such a table cooling apparatus with dust sieve, rolls, stirrers, jacket, and power shafting, etc., costs about 4500 marks.

Sliding Plate Coolers, like the Rowold hot-air drier described (p. 371 *et seq.*) and illustrated (figs. 137 to 139) above, consist of two vertical double series of sliding plates bent to a rounded angle of about 145°, arranged in venetian-blind fashion, and fixed to corresponding projections in the cast-iron wall plates. The air chambers and the vertical sheet-metal flues (*a* or *z* in figs. 138 and 139) for the introduction of heated air are, however, not provided.

The hot small coal supplied above slides in the manner depicted on p. 372 in two streams between the two double series (usually provided with $2(25+26)=102$ cooling plates). It pursues a zigzag path from plate to plate and is cooled under the action of fresh air, steadily streaming through lower openings in windows provided in the two long sides of the cooling space, and also through the long slits in the vertical wall plates into the space between the two series of plates. Finally, the air escapes through a brickwork chimney towering above the roof. The automatic sliding of the coal takes place at a rate determined by the rate of removal from the bottom in exactly the same manner as described for the wind oven (p. 372). Stoppages can scarcely ever take place, thanks to the dry, loose nature of the finished briquette coal which passes through the cooler in about 30 minutes.

It is not usual to make these coolers over 4 metres long and 5 metres

high, and the coal to be cooled is distributed among a corresponding number of appliances arranged in several cross series (batteries) one behind the other, each series containing three appliances standing parallel in the length of the cooling chamber. For six to nine presses two, and for twelve presses three, batteries are usually enough, and this is the case in the twelve-press plant already mentioned (see fig. 165, longitudinal section N–O).

The distance of the individual cooling appliances from each other in the longitudinal and cross directions should be such that a passage is left large enough for the execution of the necessary work.

The coal discharged from the apparatus at the bottom falls into a common trough of wedge-shaped section running in the longitudinal direction, and slides along the smooth brick walls, inclined at an angle of at least 50°, to the intermediate worm conveyor which then carries the coal to the press worm (fig. 165)

In practice the cooling appliance on the lines of the wind oven has given good results generally. With a completely automatic motion of the dry coal the working and labour costs are very low, and the cooling effect is very satisfactory. The briquette factory III. of Clara pit at Neu-Welzow, Lower Lausitz, serves as an example. Here the coal charged into the top of the coolers at about 65° to 62° C. is discharged at the bottom at about 40° to 35°, and in addition a thorough admixture, and, under certain conditions, a certain amount of after-drying (loss of about 1 to 2 per cent. of moisture) of the coal may take place. The development of dust is only moderate if the introduction of fresh air is properly regulated.

At the Horrem briquette factory at Horrem, boiler-tube coolers with tubes 180 mm. wide are used. The tubes are surrounded with cold water, and the dried coals and fresh air are allowed to pass through them, whereby a cooling from about 70° to 40° to 35° is effected.

Storerooms.

Owing to the introduction of suitable cooling appliances, the former very general practice of the use of a storeroom for the equalisation of moisture and temperature differences can now be dispensed with, but it is still required for the purpose of storing dry coal during interruptions in the operation of the presses, and so on. On this account it is difficult to manage without a storeroom at so many modern works provided with cooling appliances, while at works not

so provided such a store can scarcely be dispensed with. The provision of storerooms for dried coal is required by special regulations of the mining commissions.

In the Halle district[1] storage rooms must not be provided below other rooms in the factory; they must be situated at such a height that the coal does not have to be elevated on its way from the store to the presses; their walls must have no internal irregularities, and must have an inclination of at least 45°.

These conditions are best fulfilled when the storeroom is arranged behind the cooling apparatus in the elevator and cooling shop, so that in case of need it can be fed from a common central worm conveyor. This is carried out at many modern works, and also in the example of the twelve-press factory cited above. Fig. 165 shows in section N–O the length of the storeroom to the left of the cooling chamber, while P–Q shows a cross section. Its steep, long walls consist of seven narrow, flat brick arches resting on inclined iron **I** beams and levelled inside with a coating of cement. Six narrow cross walls with tie bars divided the storeroom into seven chambers extending close up to the roof. They can be filled from the worm conveyor singly, severally, or altogether according to requirements. The roof of the storehouse is, like that of the cooling chamber, made of flat brickwork arches resting on cross beams, and is pierced in the centre with a number of holes situated immediately below openings in the conveyor trough and closed by means of slides.

From one of the long walls of the storeroom there rise four brickwork exhaust flues whose main object is the removal of fine dust arising during the fall of the dry coal. Naturally this development of dust is greatest when the coal falls into an empty chamber and consequently has the greatest fall.

The coal lies in the storeroom until it is required for the operation of the presses. During the period of rest it completes the desired equalisation of moisture content, and undergoes a certain amount of cooling which is, however, limited by the closed nature of the space.

In order to control the emptying of the storehouse, each chamber is provided, at the bottom of the long wall in front of which the discharge conveyor is situated, with an opening 300 mm. wide provided with an iron mouthpiece. The upper portion of this is closed with a vertical slide, while the lower portion is closed by a small discharging roll, usually 300 mm. diameter and 300 mm. long. The roll revolves

[1] *Hallesche Bergpolizeiverordnung*, Dec. 21, 1903, § 4, No. 7.

carries and discharges an amount of coal into the conveyor below, depending upon the opening of the mouth-piece which can be determined by the adjustable slide.

The brickwork worm and roll trough is closely covered with a series of iron lids (780 × 850 mm.) corresponding to the number of chambers and rolls, resting on an inclined iron frame fixed at the top to the storeroom wall. They are held in position by catches, which can be turned by hand and permit the lids to be lifted by hand-grips.

In order readily to determine the height of the coal in the chambers without opening them, a floating iron disc is used. It is hung in the centre by a thin iron-wire rope, and rests on the surface of the coal like a body floating in a tank of water. The wire rope is led through the storeroom ceiling and over a pulley in the upper room and is loaded at its other end with a counterweight which rises through the same height as the disc falls when coal is removed from the chamber concerned. In this way an indication of the height of the coal is obtained at any moment.

SECTION VI.

PRESSING.

A. GENERAL.

In Sections III. to V. a detailed description is given of the methods of preparing the naturally occurring earthy brown coals (capable of briquetting without the addition of binding material) in the various wet and dry operations as well as by mixing and cooling, in order to render them suitable for compression into good briquettes. The removal of the finished briquetting coal from the cooling or store rooms into the upper press room, and from the press or distributing spiral, through the holes in the trough provided with slides and discharge tubes, to the charging hoppers of the individual presses, is also described.

It is now time to deal with the attainment of the object itself, *i.e.* with the preparation of brown-coal briquettes which shall exhibit certain definite external and internal properties, specified in Section II., pp. 285 to 306, and illustrated in figs. 107 to 112, according to their intended application as "domestic" or "industrial" briquettes, and also according to the special requirements of the purchaser.

While in the briquetting of pit coals a not inconsiderable number of systems of presses differing largely from each other are applied, brown-coal briquetting has been carried out since 1860 up to the present time with only a single-press system, *i.e.* the so-called Exter rope press with a horizontal open channel mould into which a press stamp is alternately pushed in and drawn out.

It was first applied in Ireland, and was then introduced into Bavaria for the working up of peat, and soon came into general use for the pressing of brown-coal briquettes.

The principle of the rope or sausage press has already been indicated in Section I., p. 176, and what is said there applies also to brown-coal briquetting, with the exception that the briquette rope pushed out of the mould is not cut up immediately as in the case of the rope press

for pit-coal briquettes, but is pushed on to a long bench to be more fully described below. With regard to the construction, there are also considerable differences.

Each brown-coal briquette press consists of three main portions combined to a complete unit:—

1. The driving steam engine with the movable press appliances,
2. The charging hopper with the feeding arrangement, and
3. The press body with accessories.

While the construction of the movable press appliances and the other two main portions has, with the addition of a few slight improvements, remained the same for the last ten years, the construction of the power plant has lately been subjected to considerable changes and improvements which have had for their main objects the increase of the output of the press on the one hand, and, on the other, an increase in the safety and economy, especially as regards diminished steam consumption. Regard must always be given to the fact that the waste or exhaust steam from the engine, etc. (with the addition of fresh steam when necessary), may be applied for heating the drying arrangements for the moist brown coal. The press steam engines, therefore, always have to work under a certain amount of back pressure (up to 3 atms.), corresponding to the steam pressure maintained in the drier, which generally amounts to between 1½ and 2½ atms.

B. EXTER ROPE PRESS (OLD ZEITZ CONSTRUCTION).

(Plate IV., and figs. 166 to 173.)

The complete press of the Zeitz construction often met with from 1890 to 1900 is illustrated in Plate IV.—(*a*) side view, (*b*) at the top—vertical section, and at the bottom, plan and horizontal section. The driving engine occupies the left portion, the power transmission the central, and the press itself the right portion of the whole plant. In the two longitudinal sections we see the horizontal channel mould or press mould *pf*, into which the dried small coal falls at the back end (left) from the hopper (not represented in the diagram) above the supply rolls *aw* at *Ke*. It is pushed by the stroke of the press stamp *ps* into the closed main circular portion of the channel, and pressed against the rope of previously pressed briquettes moving outwards.

This rope of briquettes (not visible in Plate IV., but can be seen in fig. 174), led outside the press in an iron, so-called briquette gutter, proceeds from the mouth of the channel mould to the loading track or storage shed often 100 metres away, and after the compression of a new

block is pushed forward a distance equal to the thickness of a briquette by each stroke of the stamp The press stamp with the whole mechanical arrangements of the press has therefore to overcome, first, the increasing resistance to compression exerted by the particles of coal and the walls of the mould, and second the approximately constant exterior frictional resistance of the freshly pressed block and the rope of previously pressed briquettes against the walls of the mould and the briquette gutter during the stroke When the pressure exerted by the press through the stamp exceeds this exterior frictional resistance the whole rope is moved forward. The end pressure at which the finished briquettes are prepared has been fixed at 1200 to 1500 atms Although a block is always pressed against the end of the previous one, no sticking must take place in ordinary working, but the briquettes must all acquire smooth flat end surfaces so that they are detached from the rest of the rope on taking out of the gutter The output of a press at 90 strokes per minute amounts to 129,600 briquettes (7 in) = 45 tons per 24 hours

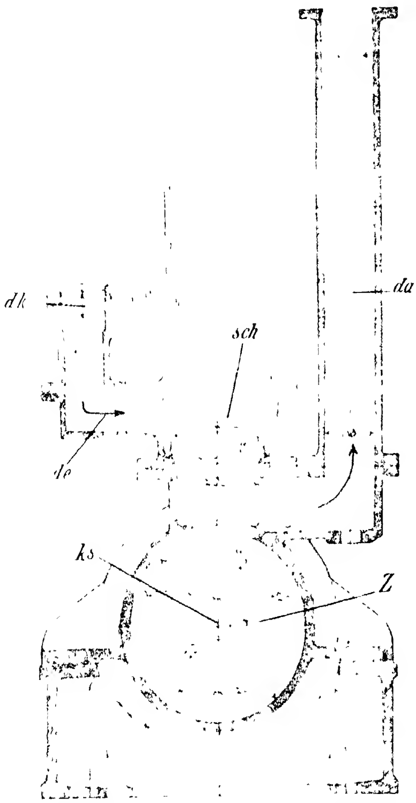


FIG. 166 —Old power machine for Exter press Cross section I II magnified. (Compare fig 167.)

1. *Driving Engine and the Moving Press Arrangements* (Plate IV. and figs. 166 to 169) -The steam engine is a horizontal single-cylinder machine. In the present example the steam cylinder Z, of 430 mm. diameter, is provided with slide valve gear. The valve chest *sch* is placed on the top of the cylinder, and on one side it is connected to the downcoming steam supply pipe *de* (fig. 166), the exhaust being removed by the pipe *da* on the other side. The steam acts on the

piston K, which sets in motion the cross head Q moving in the slide bars *gf* and the two connecting rods *ps* with their crank pins, by means of the piston rod, which is continued backwards. In turn the connecting rods set in rotation the cranked discs and heavy fly-wheels *sr* situated on both ends of the cranked main shaft W. The piston stroke

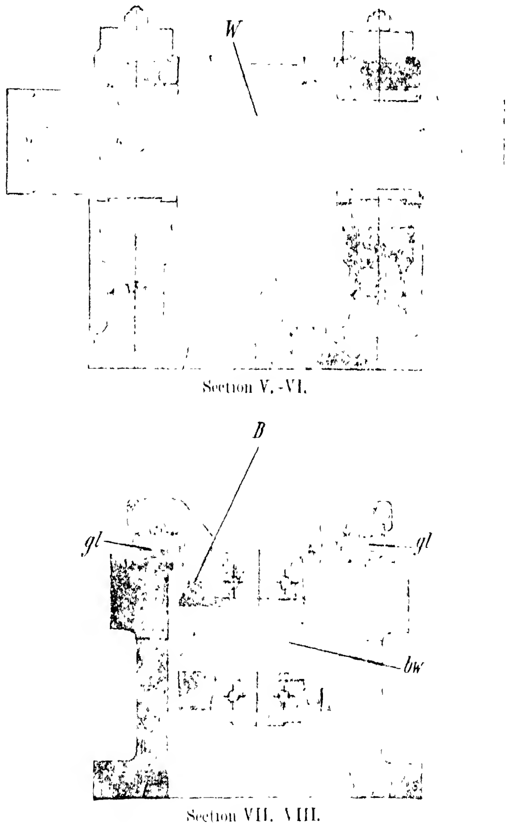


FIG. 167.—Cross sections through the moving parts of the Exter press, magnified from Plate IV.

is 630 mm., the diameter of the fly-wheels 3200 mm., and the number of revolutions 70 to 90 per minute at a super-pressure of about 8 to 9 atms.

On the cranked portion of the main shaft between the fly-wheels the rear end of the strong "ram rod" *bs* is fixed, while its front end rests on the middle of the cross bolt *bw* of the ram B. The latter is a very heavy cast-iron body moving along the horizontal gliding surface *gl* (fig. 167), the press stamp *ps* being screwed into the centre

of its head The main shaft, fly-wheels, ram-rod, ram and stamp form the movable portions of the press By means of the ram, the press stamp receives the necessary horizontal forward and return strokes which amount to about 200 mm.

It is true that a direct drive of the stamp from the piston by continuing the piston rod forward would be much simpler, but at the same time would be quite unsuitable, since the press stamp would only have to do work on its forward stroke—light at first, then increasing with extraordinary rapidity, and finally uniformly great. On the return, however, practically no work has to be performed, and for a steam engine the endeavour should be to ensure that the load is as

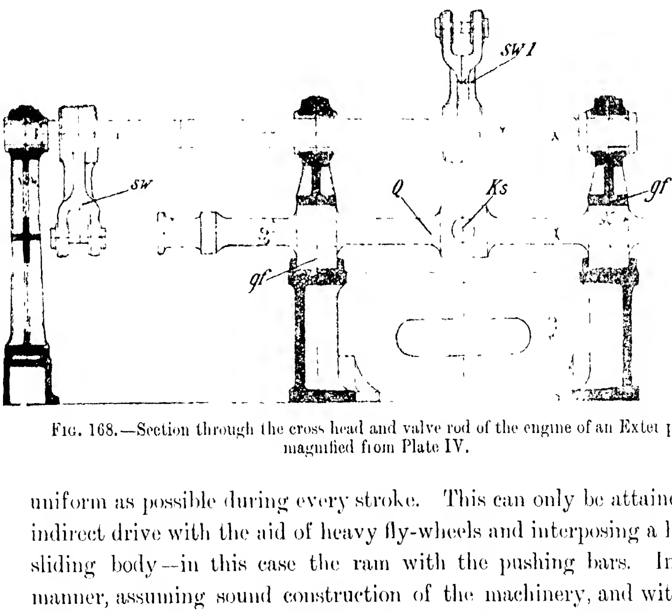


FIG. 168.—Section through the cross head and valve rod of the engine of an Exter press magnified from Plate IV.

uniform as possible during every stroke. This can only be attained by indirect drive with the aid of heavy fly-wheels and interposing a heavy sliding body—in this case the ram with the pushing bars. In this manner, assuming sound construction of the machinery, and with the aid of the valve and regulating arrangements to be described later, the great irregularities in the load during the operation of the press are equalised in a thoroughly satisfactory manner and a steady motion of the machine is assured.

Further information with regard to stamps is given later.

The motion of the simple D slide valve of the engine is effected by means of the to-and-fro motion of the valve rod *st* and the upper rocker bar *sw* (fig. 168), fixed on the lay shaft situated above the slide bars *gf*. This shaft is driven from the main shaft W by the lower rocker arm *sw*, the valve rod *st*, and the eccentric *e* (Plate IV., at the bottom).

The admission of steam to the valve chest is automatically regulated during the operation of the press by means of the governor R (Plate IV.), which is set in rotation from the main shaft by belt transmission over the pulleys *rs* and rs_1 and by a pair of bevel wheels. Every change in velocity of the machine is transmitted to the throttle valve *dk* in the steam inlet pipe (fig. 166) by means of the bell crank lever *wh* and a connecting rod.

If the press runs too rapidly owing to the admission of excess steam, the balls of the governor fly outwards because of centrifugal force, lift the upper arm of the bell crank lever and pull forward the lower arm with the connecting rod, when the throttle valve is partially closed and allows a smaller quantity of steam to enter the valve chest. When the press runs too slowly the balls of the governor fall and effect a partial opening of the throttle valve and a corresponding increase of the steam admitted

In addition to this automatic regulation, a hand regulation of the steam admission is provided by means of the hand wheel *rd* (Plate IV.), whose spindle is carried by a small column attached to the frame of the machine. According to the direction of rotation it partially opens or closes the steam stop valve at *dv*. The hand wheel is arranged immediately behind the real press, on the same side as the lever or star wheel *sr*, and in front of the fly-wheel, so that it can be reached comfortably and used rapidly by the press attendant.

It is used to cause the press to run faster or slower according to requirements, or to put the press out of action immediately when special occasions, such as after-breakages, arise.

The spindle opposite the hand wheel *rd* on the inner side of the other fly-wheel is also horizontal, but is not provided with a hand wheel. It is provided as a support for the press attendant when lubricating the bearings, etc.

Details of the press stamp will now be given Fig. 169 is a photographic illustration of the form usually employed in the manufacture of domestic or room briquettes. Four holes are drilled in the four-sided foot standing vertically, for the reception of screw bolts which fasten the stamp to the ram. The actual stamp is fixed to the foot, and is strengthened above and below by thick, cast-on ribs. It is always made in one piece, and usually case-hardend, cast steel being employed only for very soft coals. The total length, inclusive of the foot, amounts to about 425 mm. The upper and lower plane horizontal surfaces, rounded off to the vertical, flat narrow faces, are carefully

planed and polished so that the stamp is of uniform section over the whole of its working length. Its top surface is exactly at right angles to the sides, and is finished in exactly the same way. The briquette trade mark (reversed) is cut in the top surface with a sharp chisel of the hardest steel. Then the mark (MARIE, with two crossed keys on each side in fig. 169) is raised on the back of each new briquette during the operation of pressing, as can be clearly seen from an inspection of figs. 107 to 109.

Other stamps find application for industrial briquettes their shapes depending upon the intended form, number, and combination of blocks to be pressed simultaneously at each stroke of the stamp. Details of

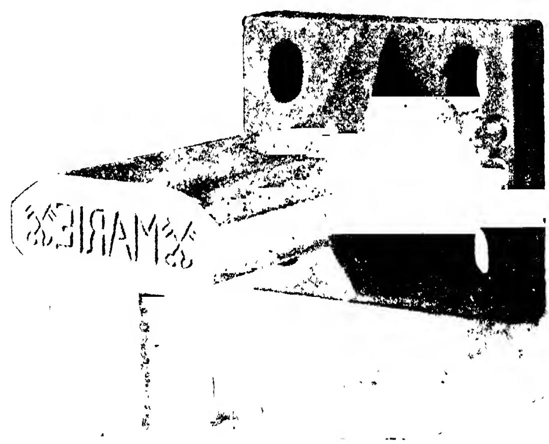


FIG. 169. Press stamp[1] for domestic briquettes.

these stamps and their accompanying shapes will be given below under "Preparation of Briquettes in Small Lumps."

The stamps wear out most rapidly on the top surface, so much so that the trade mark often becomes quite invisible after a few days, when the stamp has to be changed and recut. Further details will be given below (p. 449).

2 *The Charging Hopper and Supply Arrangement*.—The charging hopper which receives the dry small coal for compressing from the press worm (figs. 128, 164, and 165) is only represented in its lowest part—the hopper neck *fh*, below which is situated the supply appliance in Table IV.

The funnel, made of sheet iron, towers above the four-sided neck

[1] The support at the head of the stamp is not a part of it, but merely serves to hold it in a horizontal position for photographing.

of the hopper and forms either a sharp inverted pyramid of square section, or a sharp inverted cone of circular section (compare fig 174), often extending up to the roof of the press house. Each charging hopper acts as a storage bin to balance transitory stoppages in the coal-supply from above, and permits of an uninterrupted running of the press. At many briquette factories provided with neither special storage nor cooling houses, the charging hoppers, which are then made very much bigger than usual, are sometimes provided with series of alternating sharp, roof-shaped angle plates and air channels. This gives the slowly falling fine coal an opportunity of equalising differences in the moisture content or temperature, and also permits of a certain amount of cooling under the influence of the surrounding air and that which enters through openings provided for the purpose The capacity of the charging hopper usually amounts to between 1200 and 5000 kg of briquetting coal

The supply arrangement attached to the bottom of the neck of the hopper, called "coffee mill" in many briquette factories, consists of a supply or feeding roll *aa* (figs 170 and 171) revolving steadily in the direction indicated by the arrow and the upper coal slide Ks, arranged vertically or inclined in the neck of the hopper The slide can easily be regulated by hand, and leaves a narrow passage, adapted to requirements, for the coal between its lower edge and the roll In addition, the neck of the hopper above the roll is often fitted with a horizontal regulating or throttle slide, while below a strong inclined conveying plate reaching to the roll surface is provided for the removal of the coal sliding on to it from the roll The roll is driven from the steam engine by means of a thin round belt and the three-cone pulley ss (fig 171) fitted outside the hopper neck This permits of varying the speed of the roll within certain limits The roll space is covered at the front with a hinged cover (fig 175) fitted with a screw bar in some cases. In modern presses the whole supply arrangement with the hinged cover is conveniently arranged at the back of the hopper neck, where it is much more accessible Further, the coal slide Ks, instead of being fitted with a simple handle for direct adjustment, is provided with an indirect setting and fixing arrangement by means of a bell crank lever whose lower arm has a knob grip and moves in a bent link at its lower end so that it can be fixed in any desired position by means of a wing nut. Not only is a finer regulation of the coal-supply rendered possible in this way, but any unintended slipping of the slide is effectively prevented The slide arrangements

are operated either by the press attendant or the briquette manager, and the setting must correspond exactly to the thickness determined upon for the briquettes.

3. *The Body of the Press with Accessories* (*Press Mould, Setting Appliances, Heating and Cooling Arrangements*) (Plate IV. and figs. 170 to 176).—Small coal, conveyed by the supply roll, falls into a narrow

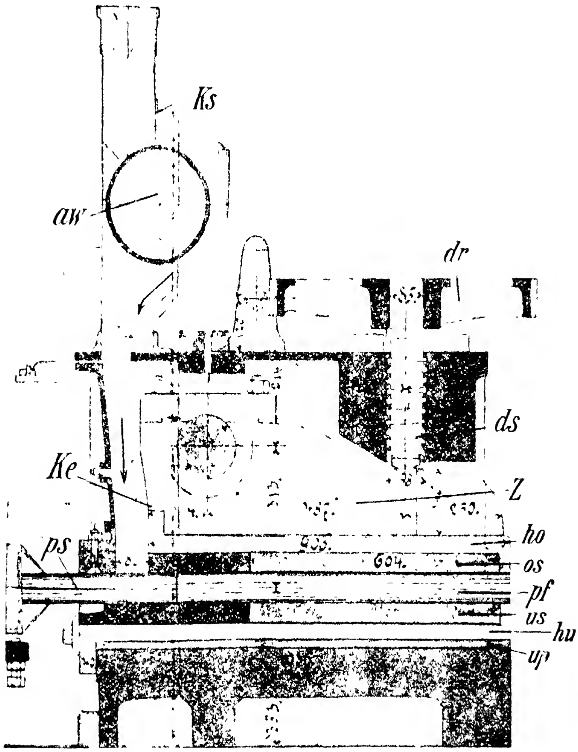


FIG. 170.—Supply arrangement and body of the Exter press. Longitudinal section.

shaft—the coal intake Ke (fig. 170)—to the rear door *th* of the press body Pr and then into the horizontal channel of the press mould *pf*. The rear door *th* (fig. 171) is fixed on horizontal outstanding bolts by two projections on each side, and is provided below with the so-called "blind piece" *bs*, which just fits the surface of the stamp moving to and fro immediately below, forming its first upper guide. By means of a screw, the blind piece can be lowered when wear renders it necessary. Another screw, acting on the top of the rear door *th*, prevents it from lifting up The rear door is also provided with a small round door

which can be easily opened to facilitate removal of the coal above the stamp when necessity arises. The real press body *Pr* of heavy ironwork forms (1) the bed for the press mould and the "tongue" Z pressing upon it, (2) the bearing for the powerful tongue shaft *zw*, and (3), the counter bearing for the pressure screw *ds* with the drive by means of the pressure wheel *dr*, the worm *sn*, and the vertical star wheel *sr*. The press body is rigidly tied to the complete frame of the whole machine, and is fastened to the brick foundation by two screwed tie rods on both sides.

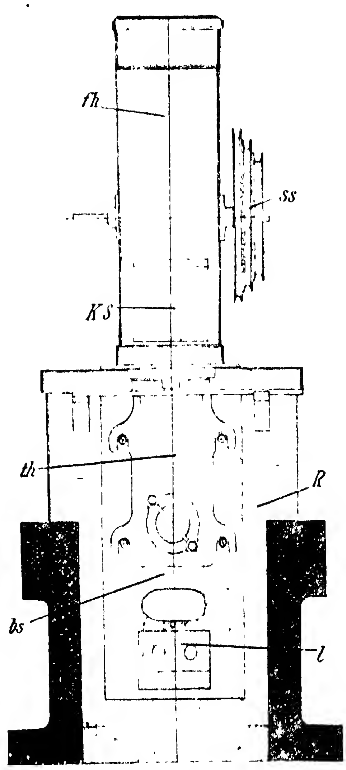


FIG. 171.—Supply arrangement and body of the Exter press. Back view.

Formerly it was made of cast iron, but since during the working of the press the mould and body have to resist the powerful pushing force of the stamp, which not only has to compress a new briquette but also push it against the rope of briquettes in the mould at every stroke, it was not an uncommon occurrence for the body to break across the middle as a result of the stresses set up by the high external friction of the briquettes against the walls of the mould.

The cast-iron body had then to be held together by means of iron bands and screwed tie rods before it could be used further. Therefore at the present time the body is made of wrought iron, *e.g.* by the Zeitzer Eisengieszerei. The greater toughness of this material provides a much greater protection against breakage.

On both sides of the mould the body is provided with hollow jaws kept closed by the bolted cover plate *rd* (Plate IV.) fitted with a close-fitting flange all round.

At the commencement of pressing, steam is admitted into the hollow jaws for the purpose of warming up the body and the mould. Later on in the operation the heat generated by the compression is so

great that it becomes necessary to cool down by the introduction of cold water. This is discussed below (p. 453 *et seq.*) in detail.

The press mould is built up of the exterior and inner portions, as shown in Plate IV., and on a larger scale in fig. 170. The external portions are: the base plate *up*, the "lower hook" *hu* resting on the base plate, the "upper hook" *ho* and the two side wedges *sk* (Plate IV.), the internal portions of the moulds are the "lower mould" section *us* and the "upper mould" section *os* (both being made up of several sections placed one behind the other), and further, one or more planed and ground thin steel plates to act as packing on the narrow sides of the side wedges.

The base plate *up*, which has to transmit the pressure of compression from above to the rigid bed-plate of the body, would rapidly become useless unless it were made of extremely strong and tough material.

Delta metal has proved to be most suitable for this purpose, and has also been found to be best adapted for making the renewable moulds, etc., for other forms of briquette presses such as, for example, the Couffinhal press of Schuchtermann & Kremer (p. 122).

The two hooks serve for the reception and fixing of the mould sections as well as for holding fast the whole mould to the rigid lower portion of the body or to the tongue 2 (see below), and also for heating or cooling according to requirements. They consist of plates 50 mm thick, formerly of wrought iron but latterly of cast steel, whose ends are bent upwards or downwards to form hook-shaped projections bent at right angles. The back projections pointing outwards lie so that the lower one rests against the rear or stamp side of the body and the upper one in front of the tongue; while the front projections, pointing inwards, support the mould sections and prevent their movement during compression. At the back, each mould section is held by an internal overlapping cover plate screwed fast to the upper or lower projection.

The upper hook together with the mould section is shorter than the lower one, since the coal-supply tube *Ke* is situated between the end of the hook and the door at the back. In order to warm the mould during the beginning of compression and to cool it during the later stages, each hook is pierced by two circular channels connected at the back and opening at the front. Steam can be introduced from a narrow pipe (or cold water from another pipe) to circulate through the upper channel, from thence to the channel in the lower hook by means of a bent connection joining the left opening of the top hook

with the left opening in the bottom hook. In this way steam or water circulates through both the hooks but in opposite directions More information on these small pipes is given below

The mould sections *os* and *us*, which are laid in the hooks, must be made so that their inner surfaces exactly fit the upper and lower surfaces of the stamp

[In German these sections are called Schwalbungen from the fact that in the shape generally used for the production of domestic briquettes they bear a somewhat fanciful resemblance to a swallow's tail (Ger. Schwalbe = swallow) when viewed from the front TR]

Their upper, or lower, and side surfaces are, however, at right angles and are always plane, so as to be adapted to the hooks and the side wedges For industrial briquettes both the mould sections and the stamps have quite another shape, depending upon the shape and size of the stones and the special combinations into which they are pressed

Further information on this point will be given below under "Production of Briquettes in Small Pieces" The lower longer mould section *us* is now often made in four (formerly three); the upper section of the mould (formerly two) of three individual sections fitting closely together, somewhat in the same way as is indicated in fig. 172 for the special case of the Grube Clara, Lower Lausitz

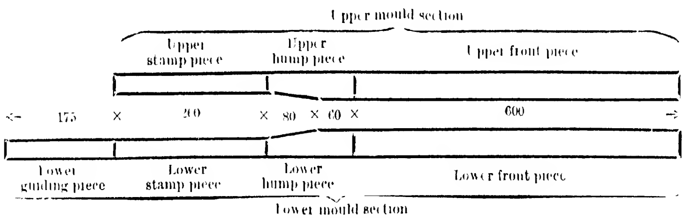


FIG. 172 -Arrangement of the mould sections in the modern Exter presses Longitudinal section.

The rear portion of the lower mould section *us*, on to which the briquette coal falls, is known as the "lower guiding section" The previously described blind piece *bs* acts as the upper guide for the stamp In this portion of the mould the stamp has no real work to perform, but has only to push the small coal before it. Immediately after the guiding section follows the stamping or working section, consisting of the upper and lower portions, between which the stamp carries out the work of compression as already described, and pushes forward the newly pressed briquette together with those previously

produced. Then follows the short contracted section, and finally the long front guiding section (upper and lower front pieces).

For a certain portion of their lengths (for the first 80 mm. according to fig. 172) the two humped sections converge slightly towards the front or to the right, but for the remainder of their lengths they are of constant thickness. This convergence causes a gradual narrowing of the section of the mould seldom amounting to more than 2 to 3 mm. There are cases in which it has been found essential to provide a bend of 6 or even 10 mm. The generally applied term "hump" (Ger. Buckel) arises from the former custom of obtaining the constriction by means of a hump-shaped enlargement of one of the central pieces — usually the upper section Naturally this enlargement was subjected to an inordinate amount of wear and tear, and as a result is now divided between both the central pieces and distributed over a more or less large proportion and sometimes the whole of the length.

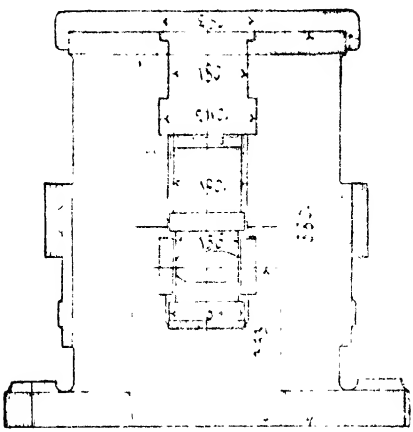


FIG. 173 —Exter press body. Front section.

The object of the "hump" is to increase the frictional resistance of the walls of the mould opposing the compression, and to further compress and strengthen the freshly pressed briquettes by forcing them through the constriction. The means is very simple, and has proved to be extremely good. Generally, it is only possible to produce good strong briquettes from hard coals by means of the hump.

The two front sections continue the narrowing effected by the hump. They and the side wedges with their linings take up the further removal of the rope of briquettes enclosed by the smooth walls of the mould held tightly together (see fig. 173), and which offer the necessary resistance to the flowing tendency of the compressed hot briquettes, which are not yet quite solid and still possess a certain degree of plasticity. At the same time the briquettes are further cooled down by the cold water circulating above and below.

The material of the mould must correspond to the somewhat varying requirements and also to the special properties of the coal to be com-

pressed. Cast steel, or cast iron or wrought iron for the sake of cheapness, could be used for the rear guiding and blind pieces which are not subjected to pressure. The stamp and humped sections, however, are subjected to the greatest stresses, and are made of the extremely resistant but very expensive case-hardened steel. For softer coals, cast steel may be employed The front guiding sections are generally made of cast steel, case-hardened steel being used only for very hard coal

The side wedges are thick cast-steel plates of the whole length of the mould They thicken slightly towards the back, and are provided at both ends with small projections turning inwards (see bottom of Plate IV.) The projections serve for holding the liners, which consist of strips of sheet steel of suitable length to fit in the wedges These strips form the inner narrow sides of the mould, and are consequently worn away very rapidly and require frequent renewal

The regulating device the principal part of which is the tongue will now be described.

The tongue Z (Plate IV and fig 170) is a tongue shaped body of cast steel or wrought iron, bolted to the strong steel shaft *zw*, about which it is capable of a certain amount of rotation To its lower surface the upper hook and mould section are attached The tongue bears on the mould and the contained rope of briquettes from the front to the back, and provides the resistance to the vertical or inclined components of the horizontal force of the compression. It is subject to the action of the pressure screw *ds* which passes vertically through the threaded, strong upper portion of the body and can be easily operated by hand by means of the vertical regulating wheel *sr* (Plate IV. figs 174 and 175) resembling the steering wheel of a ship, acting through the worm *su* and the worm or pressure wheel *dr* keyed to the head

By means of this regulating device it is possible to maintain the upper section of the mould *os* in a horizontal position for as long as required during the operation of pressing - to make the upper converge towards the lower mould section and gradually diminish the section of the mould by screwing down the pressure screw, and to increase the section of the mould by lifting the screw This will be discussed more fully below.

The steam and cooling water pipes consist of narrow tubes with flange connections branching from the large steam and water mains of the press room, and are usually led along the front portion of each body at the base of the frame. They are most conveniently fixed on the

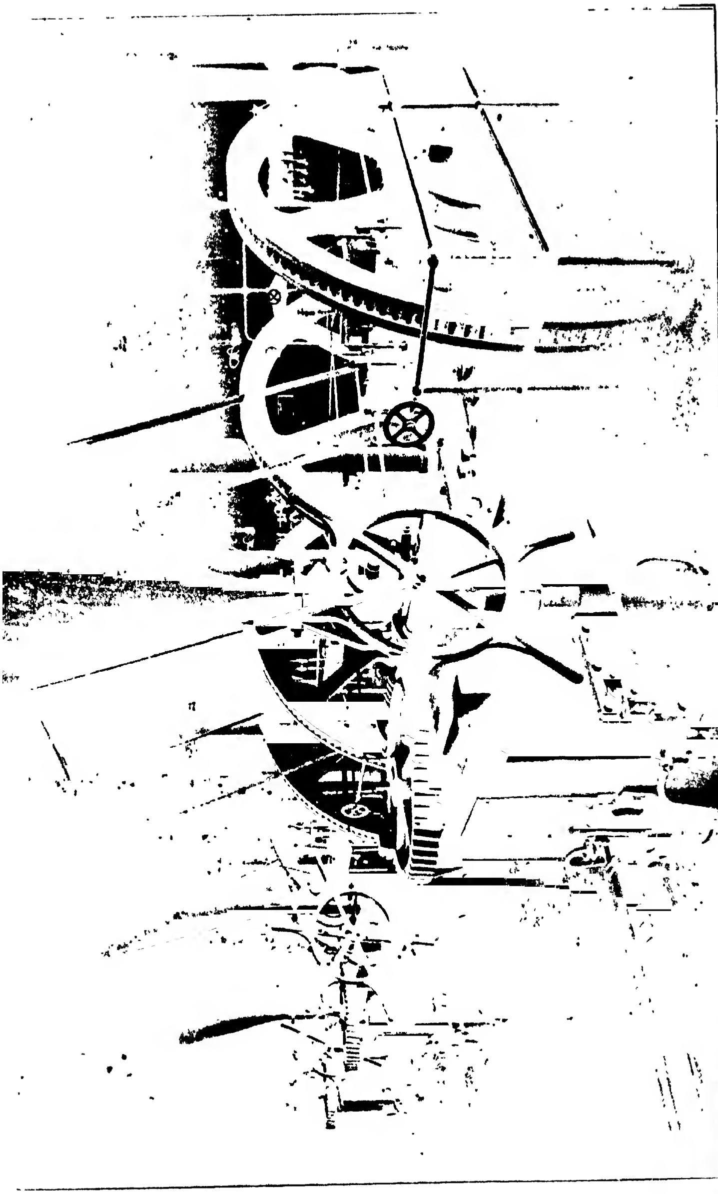


Fig. 174.—Press room with three Exter presses of Camsdorf construction showing the briquette gutters.

same side as the large regulating wheel of the pressure screw and the hand wheel for admitting steam to the engine It is of advantage to have the stop valves of the steam and water pipes close at hand The end of the water pipe opens out at an angle in that of the steam pipe, so that after closing the steam valve and opening the water valve cold water takes the place of the steam in circulating through the upper hooks, etc, of the mould For heating and cooling the hollow jaws on both sides, suitable connecting pipes are provided

Fig. 174 shows three briquette presses of the Konigin Marienhutte Akt-Ges of Cainsdorf whose construction is mainly dealt with in the foregoing description Among other details, small steam and water pipes with their valves and cocks are provided The tubes running below the briquette gutter lead away the waste cooling water Between the fly-wheels of each press there can be seen a cold water pipe hanging from an upper horizontal water main. It serves for cooling the easily heated bearing of the ram-rod in the throw of the main shaft, and is provided with branches and stop valves.

With regard to the construction and equipment of these presses and press rooms (and also in the case of Zeitz, Buckau, and other makes), the following points should be brought into prominence with reference to figs. 174 and 175 The steam cylinder is provided with a horizontal valve chest at the side, instead of on the top of the cylinder, this being of considerable advantage in the removal of condensed water. Under certain circumstances the firm also build presses with piston-valve regulation and expansion

The steam pipes are well insulated, and the whole of the bearings and gliding surfaces are provided with automatic dust tight lubricators In the middle of its circumference one fly-wheel is made like a ratchet wheel, so that during stoppages of the press for cleaning and repair work it can be moved to and fro by means of levers and pawls without the aid of steam Each fly-wheel is surrounded by a protecting fence Unlike the arrangement described above the supply rolls below the charging hopper are operated by a rising belt which receives its motion from a pulley attached to the ceiling, driven in turn by means of the engine belt shown at the right of the extreme left fly-wheel The first belt can readily be put in or out of action by means of the lever situated just in front of the charging hopper. A slide, adjustable by means of a small hand wheel, serves for the regulation of the supply. The roll chest is closed at the back by means of a bar and screw clamp

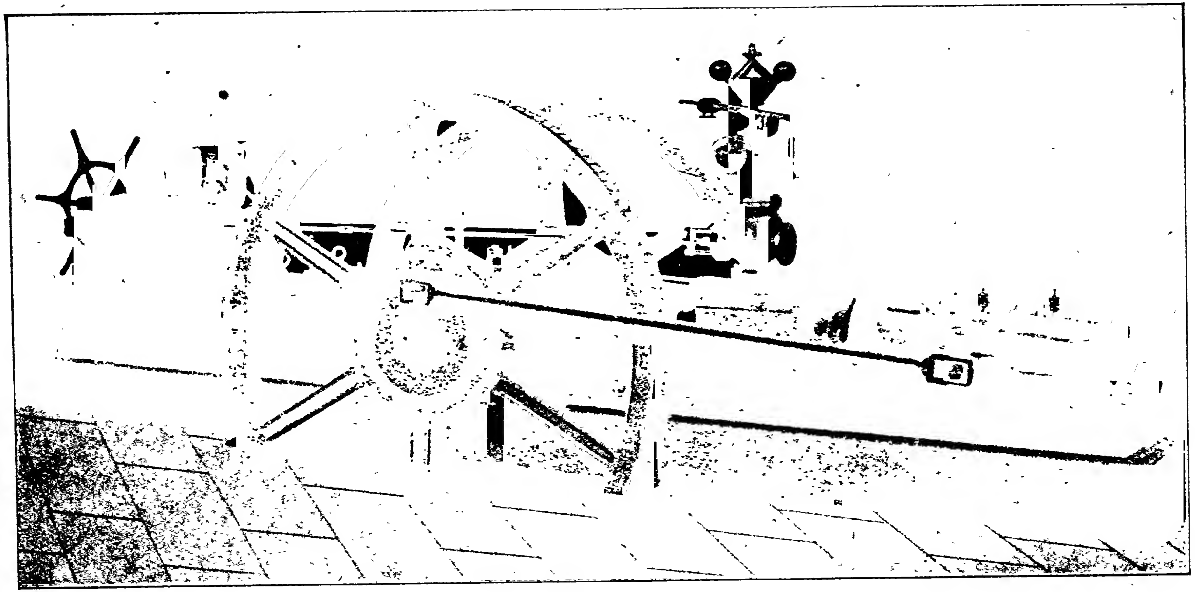


Fig. 175.—Exter press of Cainsdorf construction (without the charging hopper). Side view.

The press body is attached to the very powerful base frame by means of strong bolts on both sides. Its front portion is held just below the pressure screw by two powerful clamps, and the front opening over the mould is kept closed by means of a cover plate, which is screwed on. In continuation of the mould there is the briquette gutter carried on low brackets The gutter contains the rope of briquettes (domestic) which are being pressed out. A bar placed on the gutter in front of the opening of the mould, and having a square bolt pushed through the eyes on each side, holds the gutter together in the usual way and prevents any displacement of the upper guiding rail with a consequent fall of the briquettes. The press shop is roomy, lighted during the daytime by three tall windows and by incandescent electric lamps during hours of darkness. Modern improvements of the Exter press are described on p. 456 *et seq.*

Wear and Repair of Press Stamps and Mould Sections.—If the newly pressed briquettes show only a slight want of clearness in the definition of the stamp mark, which often occurs after comparatively few days working, it becomes necessary to change the stamp and to recut the old one. This is effected in the repair shop of the works by planing the upper surface of the stamp in a suitable planing machine, rechiselling the marks in the manner already described on p. 438, and finally hardening and smooth polishing the upper surface.

Each successive polishing shortens the stamp, and as a result it would penetrate a shorter distance into the mould channel after each operation unless packing of suitable metal strips or plates were screwed between the top surface of the ram and the back end of the stamp foot in order to compensate for the material cut away. In the case of a stamp which has not been in use very long this packing is not necessary, since the penetration into the mould at the end of the forward stroke is sufficient to permit of a slight diminution in length without seriously affecting the compression. As a result of the immobility of the falling coal and the working parts of the mould, however, it soon becomes necessary to compensate for each diminution of length in the manner described until the stamp finally becomes too short to be of use, when a new stamp has to be substituted.

It occasionally happens that the stamp breaks across as a result of not being fixed truly horizontal, or because of improper fitting of the mould sections. If the fracture is situated near the foot, the stamp, which would otherwise have to be thrown away, can be made usable again by tapping two large holes through the fracture, parallel

to the longitudinal axis, and fitting them with long counter-sunk screws in such a manner that the stamp again becomes a composite whole. But if the break has occurred at or near the top, nothing remains but to plane the metal past the fractured surface in order to save the stamp.

Of the mould sections, the stamp and hump parts, and especially the lower ones, are subject to the greatest wear and tear. In addition, the side wedges wear more or less rapidly, in from a few days to six weeks, according to the degree of hardness of the coal and lignite grains, and the presence or absence of hard foreign materials such as grains of sand or pyrites, which have a very deleterious effect. The

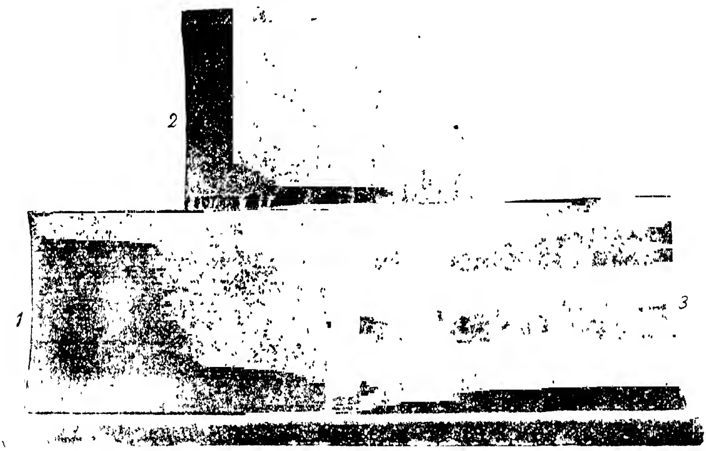


FIG. 176.—Worn mould sections from Exter press moulds for domestic or industrial briquettes.

originally smooth surfaces of the mould sections become covered, first with numerous fine longitudinal grooves, gradually becoming broader and deeper, as shown by the photographic illustrations of worn mould sections depicted in fig. 176, Nos. 1 and 3. This gives rise to the fine or coarse parallel markings so often found on the narrow sides of pressed briquettes (compare fig. 177, No. 4). In addition, fine cross scratches or snips and other irregularities are found on the surface of the working parts of the mould. Further, a flat mould-shaped hollow is easily formed across the working section just in front of the point up to which the end of the stamp head penetrates at the end of every stroke. This can readily be seen from the mould section 1 at the left of fig. 176.

It happens not infrequently that, as a result of defective fitting

knocking of the stamp breaks off large pieces from the long edges of the mould sections. Fig. 176 shows such fractured places in the section Nos. 2 and 3. Consequently, the mould sections sooner or later —usually after one to two weeks—require changing and repair or renewal. In order to examine them it is necessary to take down the whole mould every time.

To change the mould sections it is usual to first lift the pressure screw and to continue the pressing until small coal issues instead of briquettes. If the mould is very irregular the coal shows a tendency to hold together, but is thrust out without any great trouble. The stamp is them drawn back, the back door of the press removed, the hand wheel regulating the steam inlet shut off, and the ram, with its differential flange, is lifted out of the way. Now, while one worker attends to the mould, others clean the ram and guides from oil and dirt. The connecting pipes for heating steam and cooling water are unscrewed from the front portion of the body, naturally after closing the valves, the side wedges are knocked back from the front, and the lower and upper mould sections lifted out and taken apart. Such as can be replaced without repair are carefully cleansed from adhering dirt and rust particles by means of brushes and files Similar operations are carried out on the hooks and the base plate.

If the damaged portions have not become unusable by wear or breakage, they are taken to the repair shop and ground by means of rapidly rotating emery wheels which are curved on the circumference. The sections are clamped in a sort of vice, repeatedly moved to and fro horizontally, and worked up according to the shape of the stamp or the briquettes to be produced, in a manner which has to be learned by experience.

During the reassembling of the mould sections it is very essential to have a selection of various thicknesses of packing sheets and plates equal in length to the individual dovetail section. They serve to replace the loss in thickness caused by wear and rubbing and to equalise as far as possible any irregularities arising during fitting together. This prevents the formation of outstanding edges and corners liable to breakage and ensures that the blocks to be pressed shall again have the dimensions described above. Cut sections of well-rolled cardboard are used to remove slight irregularities. Fitting is carried out on a suitable heavy wooden table standing near the press concerned. At many modern installations such benches are conveniently placed in the space of ample dimensions left between two neighbouring presses. The

insertion of the mould sections in both the upper and lower hooks is effected from above, while the packing sheets, plates, or cardboard strips are laid or pushed in before or afterwards, according to circumstances In testing whether and to what extent the fitting and adjusting are good or capable of further improvement, an iron bar is usually fixed crossways to both sides of the hooks above the various mould sections, one after the other, and screwed down from above by the central bolt, provided with a hand grip, until the mould section situated immediately below has been pressed solid on to the intermediate plate and the hook. An accurate wooden or steel ruler is now placed longitudinally on the series of sections in order to test the position and extent of possible improvements. When everything is finally in order the cover plates on the back ends of the hooks are bolted fast to the mould sections in contact with them.

This important work of assembling the mould demands dexterity, experience, and care. After complete repair, the base plate with the lower hook and mould section, then the upper hook with the upper mould section, and finally the side wedges with the steel packing pieces are fixed in rotation during the rebuilding. After the top surfaces of the upper and lower mould sections, and also the side wedges if possible, are brought into a vertical plane, the pipe connections for the heating steam and cooling water are also screwed on, then the rear door with the blind piece and the felt stuffing box, which is sometimes provided, is fixed to the rear side of the body; the stamp is placed in the mould or stuffing box and again fastened to the ram, which has been pulled down again in the meantime.

Pressing: Normal Working of Press.—When the press mould and stamp is again put into proper working order, steam is first admitted into the hollow jaws of the body and into the channels of the hooks; and, as soon as the body and mould are well warmed up, damp coal, or better, coal which has been drenched with lubricating or used and recovered lubricating oil ("oil coal") is charged in, since this passes through the still somewhat rough mould easier, sticks together better, and gives rise to briquettes sooner than the dry briquetting coal. Further, the upper section of the mould, which overhangs the lower one and which, during normal working, is kept up by the rope of briquettes in the mould, is supported by a wooden peg driven into the mould channel from the back. In front of the plug the oil coal pushed in by the stamp heaps up until, on further supply and compression, the plug is engaged and is pushed back by subsequent strokes.

W. Leder and M. Schneider (Senftenberg) have constructed a special, apparently very suitable apparatus for opening out the mould by means of two rails with doubly inclined surfaces opposed to each other and a screw spindle with wedges (*Z. Braunkohle*, 1907, No. 21).

The beginning of the compression must be carried out with extreme care. While one man regulates the pressure screw, another one must have his hand on the steam stop valve. At the beginning only little pressure and "oil coal" is applied, and the machine is caused to run slowly. After a few minutes the oil coal is mixed with some drier coal, and as time goes on still drier coal is applied, until finally unmixed coal from the driers is supplied. If the latter were supplied immediately on the commencement of compression, the result would be stoppages and breakages. The pressure must be increased gradually and the speed of the machine accelerated very slowly.

The first is effected by allowing the upper mould section to converge towards the lower by turning the pressure screw to a degree depending upon the coal. For normal working the mould sections are parallel or approximately parallel for hard coal, but usually converge slightly for soft coal

The oil-coal mass issuing from the mouth of the mould after the removal of the wooden plug is not very solid at the beginning, and only yields waste. Continued pressing, however, soon gives rise to the formation of blocks in the mould channel, and continually improving briquettes are compressed until the normal properties are ultimately attained. At the beginning the briquettes appear to be scaly on the exterior because of irregularities on the surface of the mould, but if this phenomenon occurs in the middle of the working operation the cause lies either in the use of a coal which is too dry or a mould which is too hot. The control fork—a rake or forked-shaped piece of iron having three or four sharp prongs whose distance apart is equal to the predetermined thickness of the briquette—is used to test the thickness of the blocks. By means of this fork the thickness of the briquette rope is tested immediately after being pushed out of the mould and compared with the required thickness. Then the coal-supply of the press is regulated accordingly when it becomes necessary.

When passing on to normal working the original steam heating of the hollow jaws of the body and mould has to be abandoned, and as a general rule this becomes necessary after a few minutes' working. The development of heat by the powerful work of compression and friction soon becomes so great that it must not be further increased, but in fact

some of it must be removed by steady cooling. For this purpose the stop valve of the heating steam is closed and the valve of the neighbouring water pipe is opened and cold water allowed to circulate through the hollow jaws and channels.

In addition, the crank of the main shaft and the bearing of the ram attached to it also require constant cooling during pressing by cold water allowed to trickle from an upper pipe through a suspended fine rubber hose moving to and fro with the bearing of the bar.

Defective Briquettes.—Perfect domestic briquettes, as illustrated in figs. 107 to 109 (pp. 286 to 289), and fig. 177, Nos. 7 and 8,[1] can only be obtained by fulfilling all the conditions laid down in this and the previous sections.

Fig. 177 shows in Nos. 1 to 6 imperfect briquettes whose defects are of various origin. No. 1 (very much cracked) was pressed in a mould which was very much worn by being kept in service too long; No. 2 (burst on the top upper edge at the left and at the middle of the lower edge) was pressed with a stamp which had been badly screwed up and had broken loose; in No. 3 (peeling badly) the coal had been too moist; No. 4 (with a hump or "nose" on the upper and a break on the lower surface) resulted from the use of a stamp slightly fractured at the head; No. 5 shows some coarse enclosures of pyrites and is a more or less flaky briquette, and No. 6 represents a small irregular peat briquette which had been badly pressed because of wear of the stamp.

Indicator Tests on a Brown-Coal Briquette Press.—The power supplied by the steam cylinder of a briquette press in indicated horse power (H.P.) is obtained in the well-known manner with the aid of an indicator and by calculation from the recorded diagram. In the table on p. 456, the results of ten indicator tests carried out on a briquette press of 400 mm. cylinder diameter and 500 mm. stroke on 26th November 1902 are collected together. The number of revolutions and briquettes pressed per minute was 115. From the individual values of the last column the mean indicated output of the steam engine of the press for the whole ten tests is calculated to be 126·4 H.P. During the test, 7-inch industrial briquettes were pressed.

Of the indicated output of a steam engine (I.H.P.) it is well

[1] This small light briquette is a completely coked brown-coal briquette, originally of the same size as No. 7, which has been placed with other similar ones in a burning heap of briquettes, and had the gases driven off by the heat of the burning upper layers, becoming converted into an exceedingly strong coke.

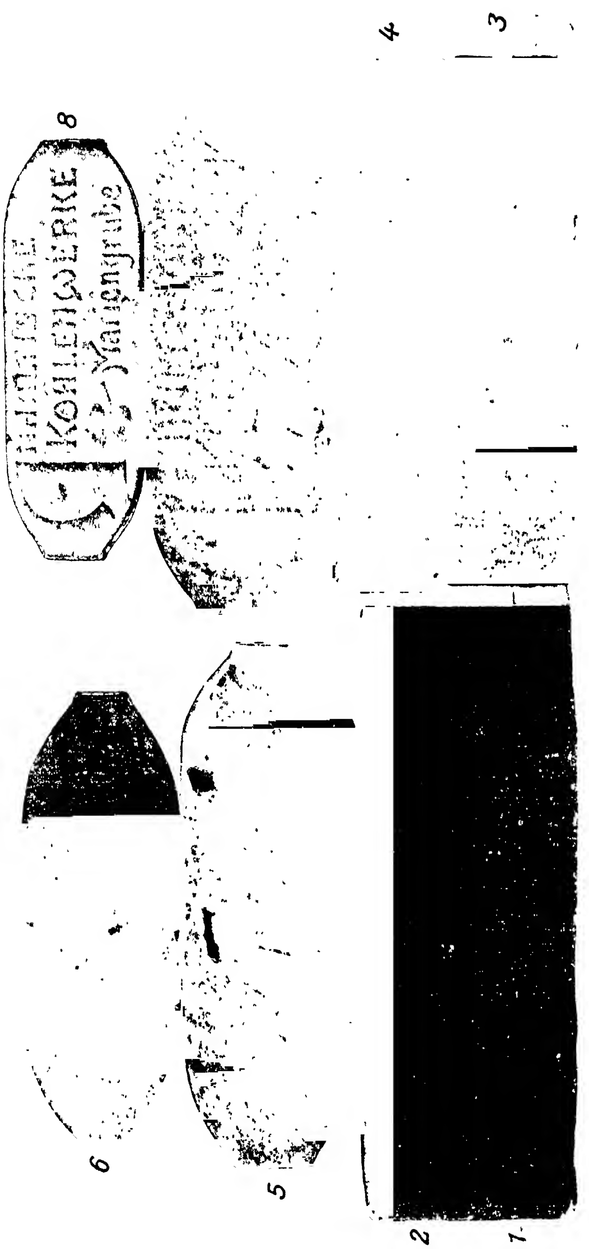


FIG. 177.—Various domestic briquettes, some faulty (1–6) some perfect (7 and 8)
(From the collection of briquettes at the Kgl Bergakademie at Berlin.)

known that a certain proportion, depending upon the design and care in construction, is lost in overcoming friction and lowers the effective horse power (E.H.P.) The ratio of I.H.P. : E.H.P. $= \eta$ is called the mechanical efficiency, and for engines of good average construction can be taken as 0·85. If, in the absence of special observations, the figure 0·85 be taken in the above case, the effective H.P of the particular press works out at $126{\cdot}4 \times 0{\cdot}85 = 107{\cdot}44$.

Diagram No.[1]	Initial Steam Pressure in the Engine.	Back Pressure in the Drying Ovens.	Mean indicated Steam Pressure (p_i) and Power I.H.P. of the Cylinder.				Total Indicated Power of the Engine.
			Crank Side.		Cover Side		
	atm.	atm	p_i.	I.H.P.	p_i.	I.H.P.	I.H.P.
1	9·7	2·3	3·53	73·6	3·36	67·0	140·6
2	9·5	2·1	3·25	67·3	3·17	61·7	129·0
3	9·7	2·1	3·34	69·7	3·26	65·0	134·7
4	9·2	2·1	3·21	66·9	3·10	61·9	128·8
5	9·6	2·1	3·31	69·1	3·14	62·6	131·7
6	9·4	2·1	2·93	64·1	2·89	57·6	121·7
7	9·4	2·1	2·96	64·7	2·89	57·6	122·3
8	9·7	2·1	3·00	62·5	2·81	56·1	118·6
9	9·7	2·1	2·98	62·1	2·80	55·9	118·0
10	9·8	2·1	3·00	62·5	2·83	56·5	119·0

C. MODERN IMPROVEMENTS OF THE EXTER BRIQUETTE PRESS.[2]

The important progress made in the construction of German steam engines in the last twenty years was not applied to the Exter briquette press for a long time. The steam used for the operation of the presses and other power units, after it had completed its work in providing power, was not sufficient to carry out further work—such as the drying of brown coals—when applied in the customary manner. It often became necessary to admit a considerable quantity of live steam to the drying ovens, so that there was no special interest in diminishing the amount of steam used in the presses and other engines.

Neither were important improvements effected in the mechanical portion of the briquette presses, since their attendance was generally entrusted to inexperienced workers; and on these grounds, in addition to the fact of continual running day and night, the deleterious effect

[1] A popular illustration and explanation of such indicator tests is to be found in Professor Richard Vater's booklet, *Dampf und Dampfmaschine*, vol. lxiii. of a popular series of scientific pamphlets issued in 1905 by B. G. Teubner of Leipsic.

[2] Walther Muller (Grube Ilse), "Fortschritte im Bau von Brikettpressen," *Z. Braunkohle*, 1907, vi, No. 24, p 396.

of the coal dust, etc., great weight was given to a design which was as simple as possible.

Only when the use of electricity had obtained a firm footing in the brown-coal industry, and when at a few works (first at the Ilse Bergbau Aktiengesellschaft, Lower Lausitz) large central stations had been erected for the operation of brick kilns, mechanical workshops, water storage, lighting installations and other subsidiary operations, resulting in the use of a greater quantity of steam in the central machines and presses than was necessary for the drying of the coal, was a change made from presses operated by the simple slide-valve gear[1] described above — which is uneconomical as regards steam consumption — to presses operated by means of expansion valve gearing.

In this way briquette presses with double slide valve gear, Meyer expansion valve gear, and throttle regulator came into operation at the beginning of the year 1890 The drive of the valve gearing and regulator was effected by an independent external shaft with a crank provided with a drag link.

Like the older type, however, these presses worked at an initial pressure of 5 to 8 atms. But when the application of higher pressures, upwards of 12 atms, was gradually resorted to, the earlier unbalanced slide-valve gearing with throttle regulator failed to meet the demands with regard to certainty in operation and steam consumption The necessity to alter the design in order to cope with the changed circumstances became more and more evident.

Fig. 178 illustrates a Buckau press dating from the year 1896 built with the above object in view It was immediately and automatically controlled by the regulator, and its operation was carried out with an open valve up to steam pressures of 8 atms. A completely balanced and enclosed piston valve was provided for higher pressures. The valve chest *sch* is situated at the side of the cylinder Z, *de* is the steam inlet, and *da* the exhaust Motion of the two valves is effected directly in the simplest possible manner by means of two eccentrics $e\ e_1$ fixed next to each other on the crank shaft W; the drive of the regulator R*e* is effected from the crank shaft by means of the belt *r*. The press body R*a*, etc., is only indicated, since its design and equipment does not materially differ from that described above.

This press was built by the Maschinenfabrik Buckau for the Ilse Bergbau Aktiengesellschaft, and gives complete satisfaction in operation.

[1] In the paper mentioned above, Muller has shown that the power lost in such a press is 75 per cent., as deduced from an indicator diagram.

When this company recently decided to take up the working of its own rubbish, which had previously been assigned to a contractor, and to instal an electric plant, the problem arose of enlarging the

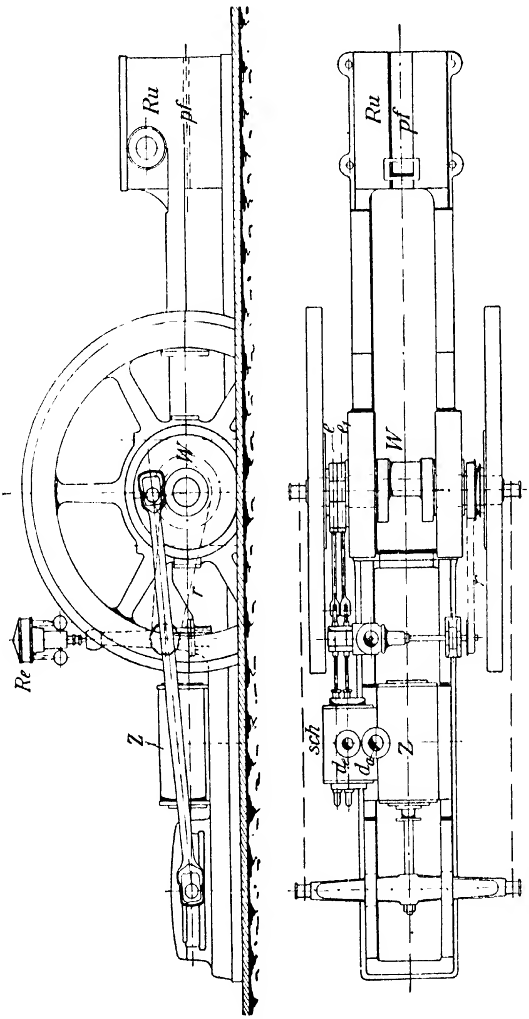


FIG. 178.—Buckau design of Exter press with Rider's expansion valve gearing (1896). Side view and plan.

central station without damaging the steam economy in the briquette factory. On these grounds the existing central machines, which were fitted with valve gearing, were converted into machines with Lentz valve gear, and at the same time the Maschinenfabrik Buckau was instructed to construct a press with poppet-valve gearing. In this

way the Buckau press with positive valve gear (Proell patent) originated in 1906.

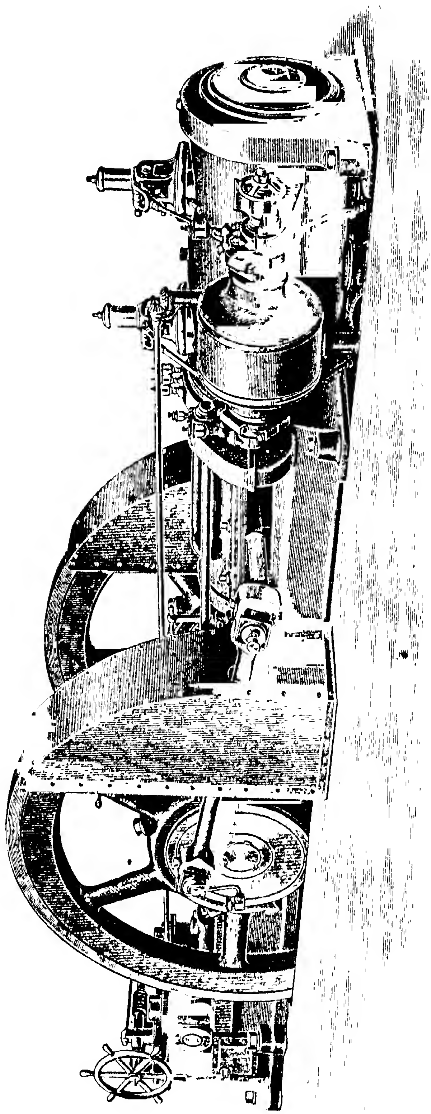


FIG. 179.—Buckau briquette press of heavy design with Proell patent positive valve gear (1906).

Fig. 179 shows the normal type of construction of this press with inlet and exhaust of the working steam underneath. In cases where

the inlet and exhaust of the steam is more conveniently effected from the top of the steam cylinder, a correspondingly constructed second type is applied; but the normal type always has the advantage of the second type, inasmuch as the pipe and cylinder condensate can be carried away with much greater facility.

The cylindrical steam-engine bed-plate, to which the cross head and guides are attached, is connected immediately to the press frame, on to which is cast the crank bearings and press body. At the top of the bed-plate the steam cylinder is attached concentrically, and is supported at its far end by a foot and special sole plate in such a way that the expansion of the cylinder under the steam heat can take place quite freely. The whole bed-plate is fixed to the foundations by means of strong stay bolts. The situation of the cross head between the steam cylinder and crank shaft is new and peculiar to this design. It provides a perfectly safe attendance to the steam cylinder and valve gearing by breaking up the old arrangement and giving freer access. The transmission of steam pressure to the crank shaft is effected by connecting rods which are one-third shorter than in the old design.

The positive valve gearing is an arrangement applied almost exclusively to modern steam engines. Its inlet appliances are directly influenced by a so-called drum governor situated in the cylindrical casing at the side of the figure and driven by bevel wheels. The exhaust valve is operated by means of a simple eccentric fixed on the valve shaft. The valve gearing is extremely simple, accessible, and noiseless. Its motion is derived from the crank shaft by means of gearing on a shaft fixed parallel to the axis of the machine.

In order to counterbalance the wear of the principal bearing, the shaft is provided with an adjustable coupling. During operation the speed of the press can be varied by means of the hand wheel at the extreme end of the valve shaft

Suitable arrangements are provided where necessary for the protection of the attendants during working.

The whole of the lubricating arrangements on the press are automatic, and freely accessible during operation. Grease is preferred for the lubrication of the main bearing, but of course oil could be used with equal facility and effect

Metallic packing is employed for making the piston rod and valve spindle steam tight because of the use of highly superheated steam.

For the protection of the engine against water hammer, safety

valves provided with hand drain cocks are provided on the lower portion of the steam cylinder.

The first press of this design was laid down and started to work in the old briquette factory at the Ilse mine, in the beginning of 1907. It conformed to the above specification in every detail. A similar press was erected at the same factory in the same year. In addition, the Anna Mathilde, Eva, and Renate briquette factories and the Ilse Bergbau Aktiengesellschaft acquired some of these new presses in the years 1907 and 1908, but as a result of the more suitable upper arrangement of the pipe lines for the inlet and exhaust steam, the second type of press, which has already been described, was applied.

Buckau Press with Positive Valve Gearing and Internal Cooling of the Ram Bearing (fig. 180).—This most up-to-date press of the Maschinenfabrik Buckau has been provided for the gigantic Marga works of the Ilse Bergbau Aktiengesellschaft at Brieske, near Senftenberg. In 1909 these works were not completed, but ultimately the installation is to consist of a total of 25 to 28 presses. The model is a press of the type which has already been indicated as normal, but has been provided with (1) a considerably improved crank mechanism with a view to reducing the surface pressure, (2) internal cooling of the ram bearing, and (3) balanced connecting rods so as to effectively prevent the to-and-fro motion of the press on the base.

The cylinder Z is provided underneath with steam inlet and exhaust pipes (d_i and d_a), an upper inlet valve v_i, and an exhaust valve v_a below. The valve rod *St* drives four eccentrics *e* fixed on the valve shaft, the inner ones actuating the two inlet and the outer ones actuating the two exhaust valves as shown in fig. 180. *Rf* is an enclosed automatic drum governor, and *hr* the hand wheel for regulating the speed of the press.

To the right of the cylinder is visible the end of the piston rod *ks* with the cross head Q, which is guided in the horizontal slot of the cylindrical frame and connected by the connecting rods *pl* (only indicated) with the two crank pins of the main shaft W and the fly-wheels *Sr*. The main bearing of the ram *bs* is situated on the cranked portion of the shaft W. In the diagram it is shown in horizontal section, and indicates the channel encircling the crank several times for the circulation of the cooling water, which is led in and away through narrow pipes.

According to Director Muller of the Ilse Bergbau Akt.-Ges., the advantages of the new design of press are as follows:—

1. The steam consumption is equal to that of the best steam engines working with the same initial and back pressures. Experiments made

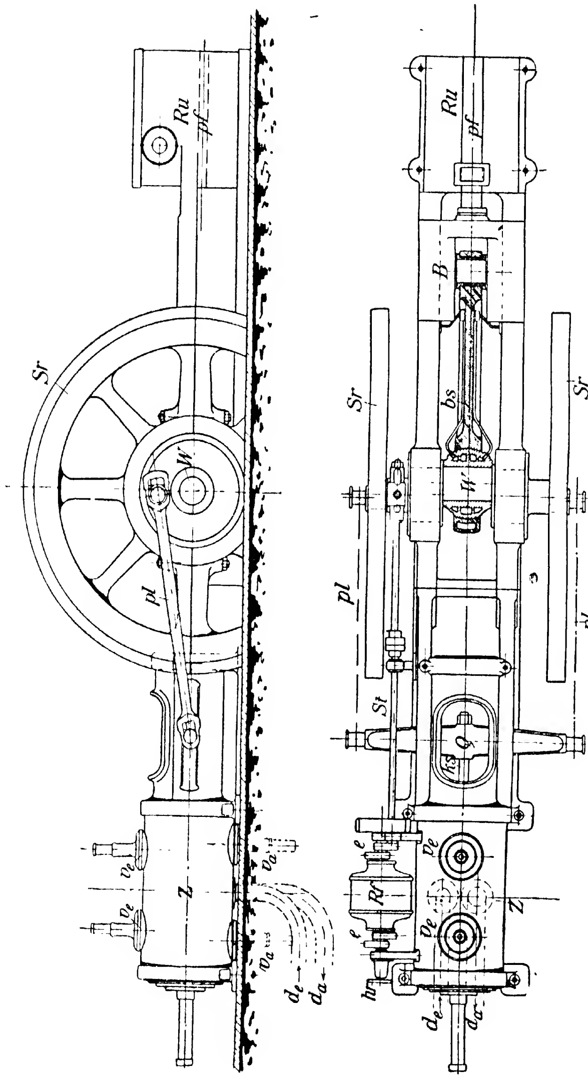


FIG. 180.—Exter press of Buckau construction with positive valve gearing and internal cooling of the ram bearing.

at the Ilse mine, with steam at an initial pressure of 12 atms. and superheated to 300° C., showed that the consumption only amounts to 10·7 kg. per indicated horse-power hour, so that, compared with a throttle-regulated press, the steam economy is about 70 per cent.

2. The application of steam at the highest degree of superheat is obviously permissible.

3. The certainty in operation is almost complete, because the drive of the valves and governor is effected by means of gear-wheels. While in the older types the press can continue even though the driving belt of the governor breaks or slips, possible fracture of the gears driving the valves can only result in automatically stopping the press A further safeguard in working (against water hammer) undoubtedly lies in the certain removal of the condensed water from the steam cylinder through the outlet valves of large section, and also in the safety valves provided as a security against all emergencies.

4. As a result of the simple and accessible valve gearing, the open arrangement of the steam cylinder, the enclosed cross-head guide bars, the housing of the fly-wheels, and the safety and lubricating appliances provided generally, the attention of the press is extremely simple and free from danger.

5. The uniformity of operation of the press is, as a result of the sensitive drum governor and the heavy fly-wheels provided, greater than is to be found in any other type. Experience gained at the Ilse mine with the presses which have been working since the beginning of 1907 has shown that the briquettes produced are of very great regularity.

6. The variations in admission, lead, and compression brought about in the older types of presses with slide-valve gearing owing to wear of the main bearing bushes, is provided for in the modern presses by a suitable arrangement of the valve gear.

7. Many years' experience has shown that the necessity for repairs to the moving parts is less in the modern machines than in those of older construction. In the latest models of presses being installed, the reduction of the bearing pressure in the main and ram bearings to approximately half, by means of special lubricating appliances for each individual bearing, and further, the possibility of a more effective internal water cooling of the ram—formerly the weakest point in the working of a briquette press,—has effectively removed the necessity for numerous repairs to bearings.

The Ilse Bergbau Akt.-Ges. offer an excellent example of the great advantage of steam economy dealt with under No. 1. At the opening of the Marga works in 1907 the steam economy permitted of about 700 H.P. being dispensed with, without interfering with the efficiency

of previous working. Further information on this point is given in a later section on power economy.

In figs. 181 and 182 diagrams from one of the new presses at the Ilse briquette factory are reproduced. Work was carried on at 2·5 atms. back pressure and 108 revs. in the first case, and 2·0 atms. and 110 revs. in the second case. The newest and heaviest Zeitz press of about 140 indicated H.P. runs at about 130 to 140 revs. per minute.

Two-Stroke Presses.—While with the generally applied simple-act-

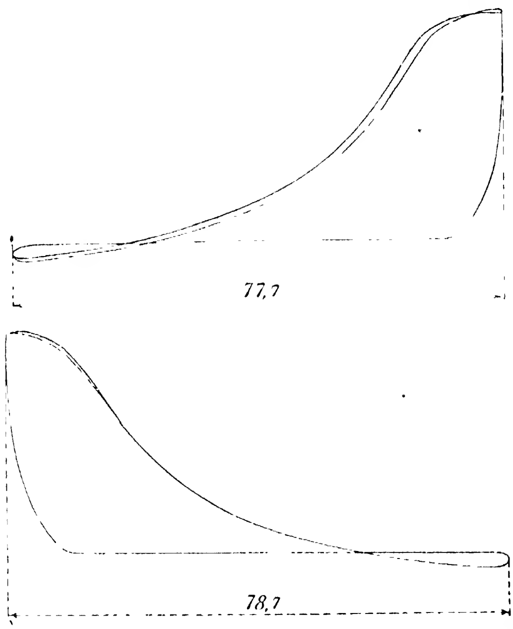


FIG. 181.—Two diagrams from a briquette press with positive valve gearing.

ing briquette presses a compression is effected and a new briquette produced on the forward stroke of the piston, the double-acting or two-stroke presses also utilise the return stroke for effective work, and consequently double the quantity of briquettes are made, *e.g.* 220 briquettes at 110 revs. can be produced.

The two-stroke press of P. Langen and A. Burmester,[1] engineers of Halle a. S., has a vertical steam engine in the centre with two equal press bodies, one on each side of the driving shaft. The presses are operated by connecting rods fixed on one and the same crank of the driving shaft. Therefore, in the same vertical plane, two ropes of

[1] *Z. Braunkohle*, 1902, I., No. 1, pp. 10–12, figs. 1–4.

briquettes are pushed out in opposite directions simultaneously. This, however, requires two special briquette yards, loading tracks, etc., at both sides of the press house, and this outweighs the advantage given above. It is not known whether the press has been actually installed at any place.

The two-stroke press of the Maschinenfabrik Buckau,[1] however, acts like a simple-acting press with only one press body and press stamp, but effects a double action by virtue of the fact that during a

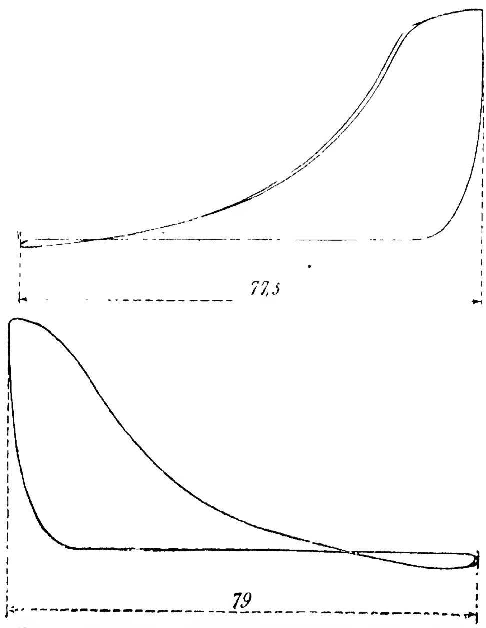


FIG. 182.—Two other diagrams from the same briquette press.

double stroke or one revolution of the engine the stamp is pushed forward and withdrawn twice by means of a suspended crank. The suspended crank, in either a horizontal or vertical steam engine, is moved to and fro by means of a crank shaft situated on one or both fly-wheels and a guide.

A press of this construction (with vertical steam engine) has been in operation since 1903 at Millygrube, near Bockwitz, Lower Lausitz, but, in spite of numerous alterations, it was not found possible to bring it into thorough and continuous working order so as to produce uniformly good briquettes.

[1] A. Scheele in *Z. Braunkohle*, 1904, iii., No. 46, pp. 616-618, figs. 346-349.

D. THE PRODUCTION OF SMALL LUMP BRIQUETTES: "INDUSTRIAL BRIQUETTES."[1]

The ordinary domestic briquettes of six or seven inches in length are not adapted for firing industrial furnaces, because—

(1) They cannot be stoked easily by means of a shovel,

(2) They hinder a uniformly dense or loose charging of the grate.

(3) They do not present sufficient combustion surface, especially where the blocks lie on their broad faces,

(4) Consequently, in conjunction with their smooth surfaces, this renders difficult their ignition and uniform combustion

Breakage of the blocks by the boiler attendants would add still further to their already strenuous work. At the same time much fine stuff is produced during crushing, and this occasions a good deal of loss It is necessary therefore to provide small briquettes (industrial briquettes, see p. 290 *et seq.*, and figs 108 to 110), especially for the needs of industrial pursuits For this purpose, however, specially built presses have not recommended themselves, because they do not permit of the production of domestic briquettes of the ordinary shape according to the conditions of the markets. In addition such presses, working with only one stamp like the ordinary rope press, were not capable of a sufficiently high output, since they produced only one small briquette as a result of a double stroke. Therefore the German brown-coal briquette industry was compelled to adopt a suitable method whereby the ordinary Exter rope press could be utilised for the production of small briquettes simply by fitting a modified press mould, and under certain conditions by the use of a suitable stamp.

Of the exceedingly large number of suggestions put forward to meet this object only those which have attained merit in practice will be dealt with here.

According to the method of C. Eisengraber of Halle and S. Neumann of Berlin, the mould is provided with projections or ribs at the top and bottom, and the stamp is provided with corresponding grooves, which respectively increase and diminish towards the exit of the briquette rope. In this way the briquettes are first furrowed, and on further pressing are broken through the furrows.

The Greppin Works of Greppin (Saxony) prefer the ribs in the

[1] Dr V. Steger, "Die Herstellung kleinstuckiger Briketts," *Stahl und Eisen*, 1905, and Z. *Braunkohle*, 1905, iv., Nos. 47, 49, and 50.

form shown at $e f$ in fig. 183 During the compression and displacement of the small coal to the right, grooves are gradually produced.

J. Treuherz (Clettwitzer Works, Lower Lausitz) divides the briquette rope up in a somewhat different way, making use of a shearing action in the mould.

One section of the rope is forced to take such a path that it is

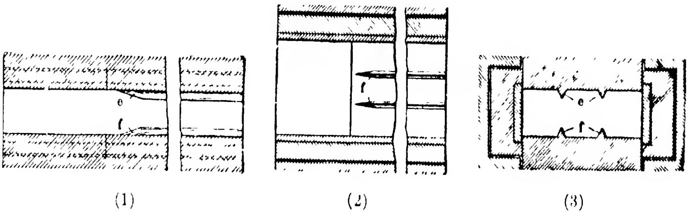


Fig. 183.—Press mould with ribs (Greppin Works). (1) and (2), vertical and horizontal sections, (3), cross section

severed to a certain extent from the other portions. Fig. 184 shows at (1) a longitudinal section through the mould, at (2) a view of the mouthpiece of the press, at (3) a longitudinal section through a mould of another type, and at (4) a cross section. In the type illustrated by

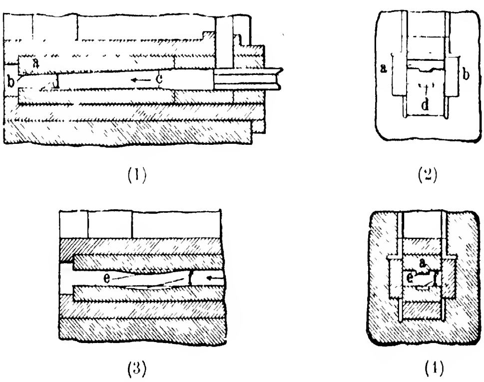


Fig. 184.—Press mould for shearing effect. (J. Treuherz.)

(1) and (2), a wedge shaped piece b is fixed to the upper mould section, beginning at c and uniformly increasing in thickness up to the mouthpiece. A corresponding groove is made in the lower piece. In this way the central portion of the briquette rope is caused to take a different path from the two side portions, and the rope becomes divided up in consequence. According to (3) and (4), however, the wedge and groove can be placed in the mould in such a way that they can

scarcely be seen from the outside. The wedge and groove fall and rise uniformly at each end.

In order to increase the divisibility of the briquette rope in the direction of its length to any desired extent, the individual sections of the mould can be made at will from any number of different-shaped lamellæ fitted together in such a way that they compel the briquette rope to traverse different channels in which breaking up is effected.

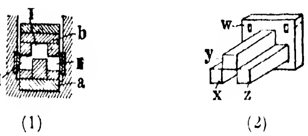


FIG. 185.—Mould and stamp for three press channels placed contiguously. (C. Buschius & Co.)

The press arrangement of C. Buschius & Co. of Berlin solves the problem in the following manner:—Three, or even more, press channels I., II., and III., fig. 185, are arranged close to one another in such a way that several briquette ropes are produced by one stroke of the stamp. The briquette ropes are either held together by narrow fins or, if a section stamp such as x, y, and z in fig. 185 is used, are produced separately.

At the Deutsche mine of Baumeister & Sohne in Bitterfeld, industrial briquettes are produced in a much simpler manner by the use of stamps cut step-wise with an unchanged or simply a rectangular-shaped mould. Fig. 186 shows the elevation (1) and plan (2) of a stamp for double, and at (4) and (5) the elevation and plan of a stamp for triple, briquettes. At (3) and (6) are to be seen the briquette ropes produced in this way. The stamps are cut away step-wise on the pressure surface, and the coal-supply is so regulated that the blocks acquire a thickness equal to the height of the step.

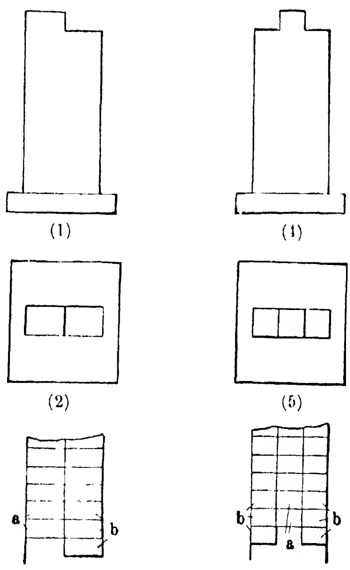


FIG. 186—Stamps with one and two steps (Baumeister & Sohne) and double and triple briquette ropes produced with them.

As a result, two or three blocks are prepared at every stroke. Since each new briquette a (3) is formed against the smooth inner or step surface of the previously pressed neighbouring briquette b,

adhesion cannot take place, and the surface becomes smooth, though not to the same degree as the surfaces produced against the outer, upper, and lower surfaces of the mould. In a similar way the triple stamp produces three smooth briquettes at every stroke. Separation takes place on leaving the briquette gutter without further trouble.

For double briquettes, it is possible to use the same moulds with the concave surfaces used for ordinary domestic briquettes. In this way the "semi-stones," of the shape of bisected domestic briquettes (pp. 291 to 292, fig. 109, Nos. 7 and 8, and fig. 110, No. 7) are obtained. Such briquettes are used especially for firing in cooking ranges and in

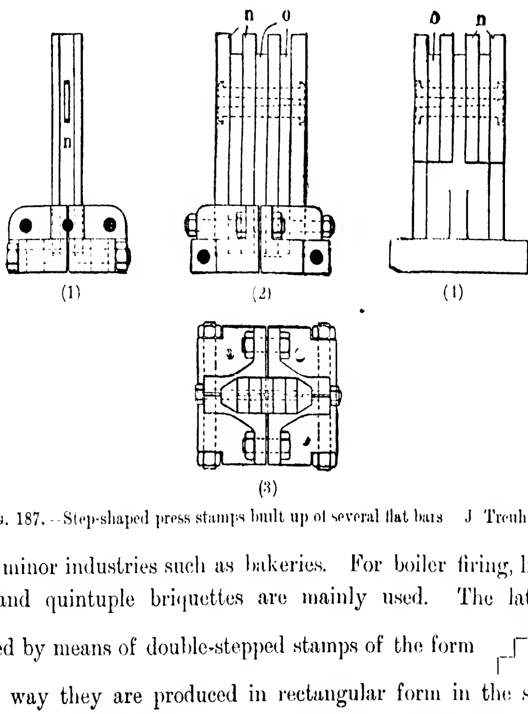


FIG. 187.—Step-shaped press stamps built up of several flat bars (J. Treuherz).

certain minor industries such as bakeries. For boiler firing, however, triple and quintuple briquettes are mainly used. The latter are produced by means of double-stepped stamps of the form 

In this way they are produced in rectangular form in the shape of three or five neighbouring ropes of cubical or nut briquettes as shown in fig. 108, Nos. 5*a*, 9, 9*a*, 10; fig. 109, No. 9; and fig. 110, Nos. 1 to 5. Rectangular briquettes have the important advantage of providing a corresponding increase of content and weight and consequently offer a greater output per press. At the present time the method just described is by far the most prevalent.

J. Treuherz of Berlin has made up step-shaped stamps of a number of flat bars as shown in three different views in fig. 187. The various

long bars n, o are held together by means of wedges, bolts, or in some similar fashion. To obtain effective fastening, one of the bars is made in one piece with the foot of the stamp (4). It is still more effective to make foot of the stamp in two or four parts which can be bolted together (1 to 3). Possible breakage of a part of the stamp then only entails the replacement of that particular section.

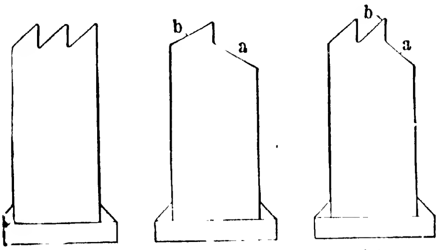


FIG. 188.—Toothed stamps with inclined surfaces Friedr. Krupp Akt.-Ges. Grusonwerke.

The process of burning is greatly facilitated if the surfaces of the small briquettes are cut at very acute angles. Consequently, the Friedrich Krupp Akt.-Ges. at their Gruson works in Magdeburg - Buckau have designed stamps with inclined surfaces (fig. 188) for the production of briquettes of rhomboidal section which adhere only quite loosely. From the original saw tooth-shaped stamps (1) in which the inclined surfaces tend towards a side displacement of the stamp, practice has gone over to the use of stamps for double or triple briquettes (2 and 3) in which one surface a inclines to the right and the others b to the left. In this way the effects of the various pressures on the sides are equalised.

Stamps possessing an apex formed by two surfaces inclined in opposite directions give briquettes of the shape illustrated in fig. 110, p. 292, No. 6.

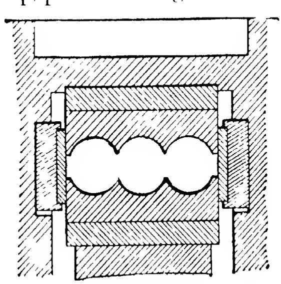


FIG. 189.—Section of cross corrugated moulds for pressing briquettes. F. C. Th. Heye and Konsolidierten Sollinger Braunkohlenwerke.

F. C. Th. Heye of Annahutte, Lower Lausitz, and the Konsolidierten Sollinger Brikettwerke of Volpriehauser, near Uslar, manufacture briquettes by compressing the briquette material by means of cross corrugated moulds and corresponding stamps (figs. 189 and 190). The briquette rope issuing from the body of the press is cut by means of knives.

Fig. 191 shows the arrangement of strong knives c on a cross stage d of the briquette gutter e. The briquette travels on the ⊔-iron f (1) or the rail g (3).

Fig. 192 represents another and decidedly better delivery arrange-

ment with cutting rollers h, revolving on the adjustable axle i, and flat vertical knives k fastened to the briquette gutter e immediately below. The knives and circular cutters are best placed just in front of the edge of the briquette gutter. The three sections are approximately circular in shape (see fig 193, and fig. 108, p. 287, No. 9 and 9a).

At the Kraft briquette factory six-sectioned briquettes are prepared by a similar method, but with the use of larger and not so deeply grooved moulds and stamps.

Later it was discovered that unfurrowed briquettes can be split

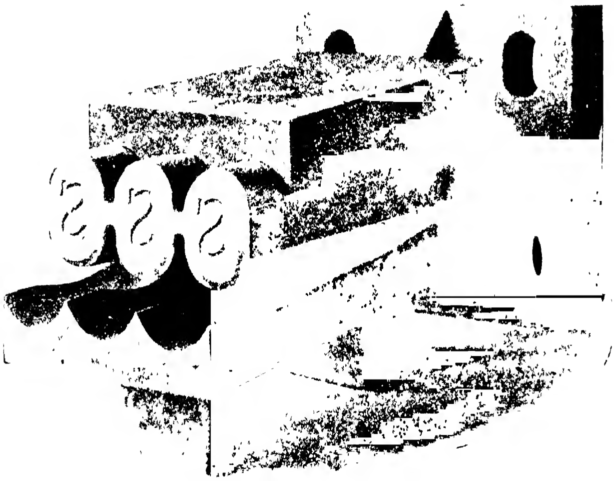


FIG. 190 Stamp and mould (considerably worn and broken on the outer edges) for corrugated briquettes

up under the force of the press stamp if, after exit from the body of the press, they were opposed to the whole cutting edge of sharp knives standing vertically above the briquette gutter.

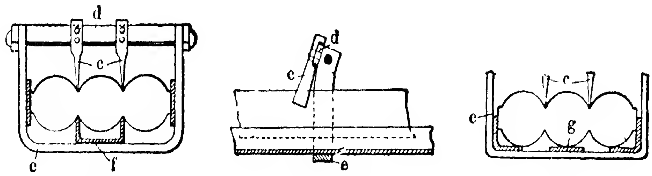
In fig. 194 quartering is provided for, the knife x first dividing the briquettes into halves, after which the knives y again divide up the sections.

The knives wear out very rapidly and need constant replacement and re-sharpening. Fine waste obtained during the division of briquettes is caught in bins below and then used for firing boilers

Schirach's Appliance for the Recovery of the Coal falling from the Stamps (fig. 195).[1]—In the ordinary press arrangements (fig 170) a small amount of coal is carried away on each return stroke of the

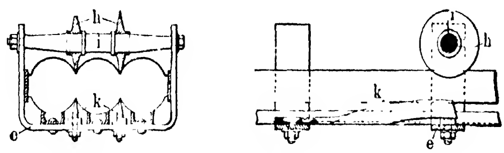
[1] *Z. Braunkohle*, 1902, No. 27, p 328, fig. 133.

stamp. This coal falls over the back opening of the mould into the ordinary stamp waste channel, where it is lost for the purpose of pressing. The appliance patented by W. Schirach of Helmstedt



(1) Section. (2) Side view. (3)

FIG. 191.—Briquette gutter with strong cutting knives.

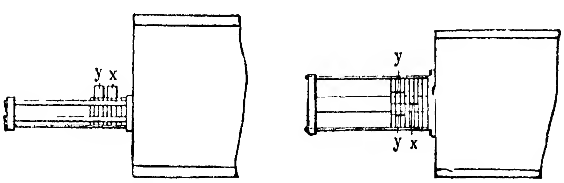


(1) Section. (2) Side view.

FIG. 192.—Briquette gutter with knives below and revolving circular cutters above.

(1) (2)

FIG. 193.—Complete corrugated briquette and the sections obtained therefrom.



(1) Side view. (2) Plan.

FIG. 194.—Division of ungrooved briquettes by vertical knives.

catches the coal falling from mould *a* in the horizontal worm conveyor *b b′*, which conveys it to the pits *c c′*. The inclined ascending worms *d d′* driven from a shaft *e* and bevel wheels *f f′* lift the coal into the hopper tubes *g g′*, which lead the coal back to the bin *h*, from whence it again falls to the stamp in the mould *a* as a result of the periodical opening of the flap *i*. This apparatus, which can be used in

a one-sided form, has been used on many presses for some years with satisfactory results.

It is very much simpler, however, to make the stamp tight by the use of Bohm felt stuffing boxes. Such stuffing boxes, with re-

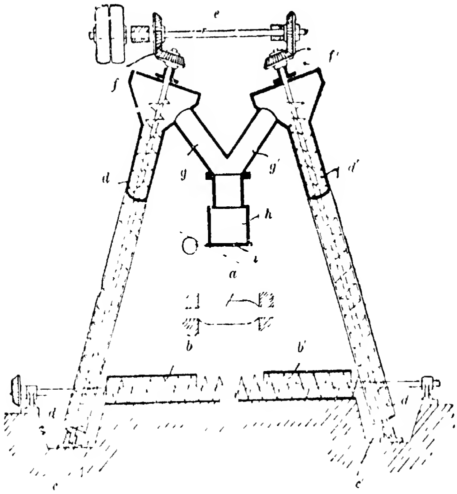


FIG. 195.—Schirach's appliance for recovering waste coal from the stamps. Vertical section.

newable felt packing, built in two sections so as to be capable of being clamped above and below the stamps by means of winged nuts, have proved themselves quite efficient after several years' use on the whole of the presses at the Grube Clara at Neu-Welzow. Even the fine dust is held back, but the apparatus needs the most careful attention and must be kept in good repair.

SECTION VII.

THE PREVENTION AND EXTINCTION OF DANGERS FROM COAL-DUST FIRES AND EXPLOSIONS. DUST-CATCHING APPLIANCES.[1]

A. GENERAL.

1. SOURCES OF COAL DUST.

THE greatest nuisance in brown-coal briquetting is the dry coal flue dust. It arises from the finest particles of coal, which are unsuitable for briquetting (see pp. 280 to 282), produced during the drying and diminution in weight, and is added to during the conveying and further treatment of the dried material already dealt with in sections IV., V., and VI.

During the drying operations considerably more dust is produced in tube driers, where the dust particles remain in heaps during the whole period of drying and generally become overheated, than in table driers which are provided with sieves (see pp. 385 to 386).

In and about the tube driers a specially large amount of dust is whirled about on the one hand because of the frequent turning by means of the turning bars (pp. 410 to 411), and on the other because of the fall of the dry material into the oven worm, more particularly when the height of fall is great. In the table ovens, however, the whirling of dust by the stirring and shovelling appliances and during

[1] Above all see:—Gertner, "Ueber Entstaubungsanlagen in Braunkohlenbrikettfabriken," *Z. f. Berg-, H.- u. Sal-Wesen i. Pr. St.*, 1908, lvi., vol. B, pp. 257–346, with forty figures in the text and three plates; reprinted by Wilh. Ernst & Sohn, Berlin, 1908. See also:—A. Scheele: "Ueber Staubabscheider in Brikettfabriken," *Z. Braunkohle*, 1902, i. p. 313; "Die Entstaubung in Brikettfabriken," *Z. Braunkohle*, 1906, v. p. 439. L. Seemann, "Ueber die Einrichtungen zur Entstaubung der Braunkohlenbrikettfabriken," *Jahrb. f. d. Berg.-, H.- u. Wesen i. Kgr. Sachsen*, 1904; reprinted by Craz & Gerlach, Joh Stettner, Freiberg, 1905. Richter in his book *Die deutsche Braunkohlenindustrie*, 1907, ii. pp. 46–49. Baldus, *Ueber Entstaubungsanlagen im rheinischen Braunkohlenindustriebezirk*, Gluckauf, Essen, 1908, Nos. 49 and 50.

the fall through the slight distances between the tables is, to all intents and purposes, inconsiderable. In removing the sieved dust from the last table and conveying the whole of the dried material through the discharge tubes into the oven worm, considerably more dust is developed, but never so much as in the case of the tube driers. Sudden admission of air into the oven, which may easily occur if there is a draught from open doors and windows, especially on the wind side of the oven shop, must be rigorously prevented.

During conveyance and further treatment of the dried material up to pressing, fresh dust can readily be formed by friction. The dust is mainly whirled about by the worm conveyors, elevators, and during the dropping of the coal through vertical pipes In addition, the drum sieves and after-rolls generally applied with tube driers, table and boiler tube coolers, the storerooms, the supply appliances for the presses and the press stamps, are also sources of considerable quantities of dust.

The finest dry flue dust has practically no weight, something like the motes in a sunbeam It only settles with difficulty in still air, but much more slowly in moving air. The greater the inclination of the coal (according to its nature) towards the formation of dust, the greater the drying ovens and similar arrangements favour the development and whirling of dust, and the more rapid the natural or artificial current of air passing through the drier or other appliance, the greater the amount of fine and moderately fine dust carried away in the exhaust vapours.

II. Dangers from Dust.

1. The particles of dust which are not kept back in the factory in some way escape into the open, are blown about, and ultimately settle on the roofs and yards of the briquette factory or on the surroundings such as houses, trees, bushes and plants, and even penetrate into living rooms If this occurs in considerable quantities, risks of fire arise, especially in hot dry seasons, the growth of trees and plants is retarded, and living in the neighbourhood of a briquette factory may become intolerable. It suffices to state that a danger to the community arises against which the assistance of the State authorities has been successfully invoked.

For example, the Kgl. Oberbergamt Halle has ordered that exhaust gases issuing or sucked from the driers and all other similar working appliances containing dried coal must be freed from accompanying coal—in special dust-catchers if necessary—to such an extent that all dangers to the community are obviated

Under the pressure of these or similar legally enforced regulations and safeguards against danger, success has been attained in the course of years in limiting the dangers by the development of suitable methods and appliances, in spite of the great difficulties opposing an effective removal of the dust from the waste gases. Experiments are also in progress with a view to still further improving the extraction of dust.

2. If dust escapes from the operating appliances into the shops of the factory, the results may be prejudicial to health, and endanger the lives of the staff, the working, and the factory property of the owner.

The prejudicial effects on health resulting from lingering in an atmosphere saturated with brown coal dust consist not so much in affections of the breathing organs as in a powerful irritating effect on the eyes, which soon become inflamed; in addition, the liver, spleen, and lymphatic vessels are affected.

III. Risks of Fire and Explosions.

The dangers to life and property depend upon the fact that dry (especially over-dried) brown coal dust is ignited very easily. Once ignited, fires and explosions with more or less disastrous effects may occur according to the quantity and distribution of the layers and whirling dust. In the first ten years of the briquetting industry a not inconsiderable number of factories were partially or completely destroyed in this way, and a large number of men were killed, or very badly injured.

Dr Rud. Holtzwart and Prof. Ernst von Meyer of Leipsic made a lengthy series of experiments in the years 1889–90 on the causes of explosions in brown-coal briquette factories.

These experiments were instigated by a committee of manufacturers at that time formed at Halle a. S. under the presidency of Bergrat Schroecker.

The most important results of the tests are as follows:—[1]

(*a*) Gaseous mixtures, occurring in the drying ovens, storerooms, and worm conveyors, are free from risks of explosion so long as the working is normal, *i.e.* so long as a fire of fairly large proportions does not break out at any portion of the plant.

(*b*) Brown coal yields—even when it undergoes smouldering at abnormally high temperatures (upwards of 400° C.) in a slow current of air—mixtures of gases which, in consequence of the high content

[1] According to Prof. Ernst von Meyer's report of Januury 6, 1891 (only reproduced by lithographic printing).

of carbon dioxide and the usually low content of inflammable gases, are not explosive. There is no foundation for the assumption that even at relatively low temperatures brown coals evolve dangerous quantities of hydrocarbons.

(*c*) The first and only dangerous agent is the fine dry coal dust when set in motion (whirled about), whereby it becomes widely distributed and surrounded by air or oxygen. Even then, however, the danger only becomes threatening when it finds an opportunity of igniting.

(*d*) The primary cause of an explosion in a brown-coal briquette factory is the origination of a local fire of glowing coal dust (see below).

(*e*) An initially diminutive ignition of whirling glowing coal dust propagates itself very rapidly into a disastrous explosion if sufficiently supported by the presence of fine dust spread over large areas subjected to the free access of air. In this way large volumes of gases (carbon dioxide, carbon monoxide, and small quantities of hydrocarbons) are produced and are expanded by the enormous heat evolved. Such an extensive ignition has in it all the effects of an explosion.

(*f*) This can still be attended with fatal results. Since a portion of the dust is incompletely burnt with the production of inflammable gases, the latter, by admixture with incoming air, form a sort of detonating mixture (oxygen plus hydrogen) which, in contact with particles of glowing carbon, explodes violently. As a matter of fact, such phenomena—vigorous ignition followed shortly afterwards by a violent explosion—have often been observed.

The fearful devastation which can be caused by explosion and conflagration is clearly shown by figs. 196 and 197, reproduced from photographs taken by Hermann Meyer of Senftenberg. The figures show the ruins of a very old briquette factory in Lower Lausitz which was almost completely destroyed in the midsummer of 1907.

The drying house, which was situated between the portions of buildings still standing (fig. 196), was the most completely destroyed. In the heaps of wreckage the remains of steam table driers and accessories (stirrers, jackets, columns, pipe lines, etc.) can be recognised. Several halves of steam tables have been brought out of the rubbish and placed in front of the press house This and the house standing opposite have only been affected to a limited extent by the explosion, but they have been for the most part burnt internally and the roofs have fallen in Bent briquette gutters lie about the open space in front. To the left of the press house a communicating bridge covered with corrugated iron is badly bent and half fallen down

Fig. 197 illustrates particularly this portion of the gutted factory. At

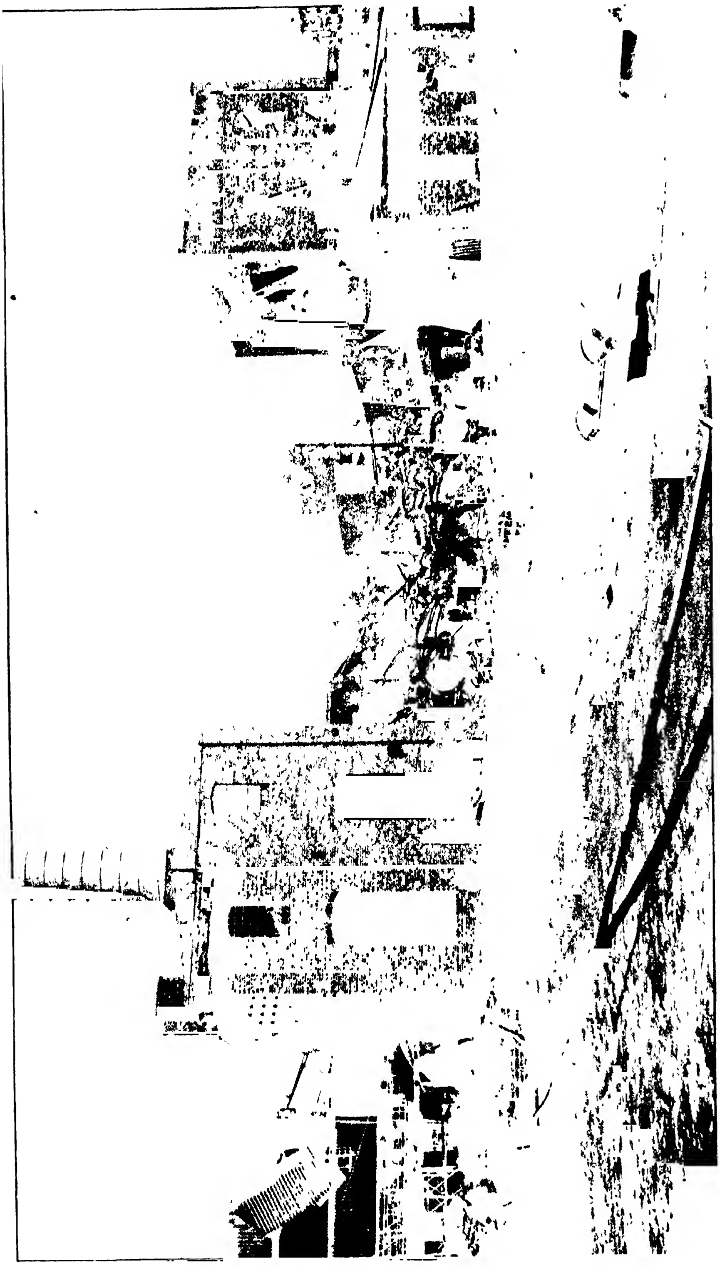


FIG. 196.—Ruins of an old Lower Lausitz briquette factory almost completely destroyed by fire and explosion. I.

the end of the bridge used for the conveyance of coal by means of a band conveyor is seen a portion of the brickwork of the outer wall of the building whose debris covers the ground. A partially damaged steam table drier has

FIG. 197.—Ruins of an old Lower Lausitz briquette factory almost completely destroyed by fire and explosion. II.

been exposed by the fall of this wall. This leads to the conclusion that an explosion also took place here, although considerably weaker than that which occurred in the completely devastated drying house (fig. 196).

The briquette presses, in the ground floor of the building in front of the drying room, were saved from excessive damage by the operations of ex-

tinguishing the fire, which were carried out with great energy immediately after the catastrophe. The exact cause of the explosion could not be determined with certainty, since the workers employed in the drying house at the time unfortunately met with their deaths.

A similar disaster was caused by a violent explosion at the Saxonia briquette factory at Zeisholz, Upper Lausitz, in March 1913. According to A. Scheele's classical description and investigation,[1] the outbreak originated in the storeroom from an insignificant fire, which probably owed its origin to an electric spark.

In order to combat the danger of explosions, it is above all necessary to prevent the origin of anything favouring conflagration or increasing the effect of explosion. Further, appliances must be provided to break the force of a conflagration or explosion and to extinguish it, since even with the greatest possible care the development of small fires cannot always be prevented.

IV. Prevention of Coal-Dust Fires.

Dry coal dust ignites or begins to glow at relatively low temperatures (about 250° C.), especially where it is heated for prolonged periods; on the bent tubes between the steam tables and their pipes and also on their columns; in obstructed tubes of the tubular drum driers; in the lower bearing of the drier; in the bearings of worm conveyors and dry elevators, particularly if the bearings are insufficiently lubricated and are allowed to run warm. Coal dust can also be readily ignited as a result of the decomposition of pyrites, by sparks such as originate from the chipping off of the corners of press stamps, or arise from the boiler or other fires. In the latter case the sparks enter the storerooms, elevators, or the like by way of the dust exhaust flues. Electric sparks, open lights, or any other burning materials are also dangerous.

These various possibilities, which in numerous cases have been determined on as causes of conflagration by exact experiments, have been provided for as follows in the recent Mine Inspection Protective Regulations, *e.g.* in the Oberbergamtsbezirk Halle:—[2]

The installation of driers with direct drying by fire is prohibited; the operation of the few existent fire-heated ovens in the Halle district is dealt with by certain definite regulations on p. 370.

Appliances must be provided for indicating the temperature or pressure of the heating steam at any moment. The surroundings of

[1] *Z. Braunkohle*, ii., 1904, No. 49, pp. 653–659, figs. 356–360.
[2] § 5 of the Halle Bergpolizeiverordnung, Dec. 21, 1903.

the dry elevators, the flues, channels and pipes used for the introduction of the coal dust, with the exception of the exhaust flue of the drier, must be protected against the admission of sparks by suitable appliances at their open ends

All bearings in the working appliances filled with coal dust during the operations must either be provided with automatic lubricators or with such that can be operated externally.

The lower bearing of an inclined tube drier must be completely outside the dust chamber attached to the discharge side of the drier.

Artificial illumination[1] must be provided for the whole of the rooms in the factory. The lighting of those rooms in which a development or an entry of coal dust can take place must be incandescent electric The glow lamps must be protected by tightly enclosing globes, and portable glow lamps must in addition be surrounded by a strong wire cage Further regulations govern the illumination of other rooms in the factory the number of lamps and flames, the special driving of an occasionally used lighting dynamo, and the introduction of glow lamps or emergency lanterns (oil lanterns or candles) into the passages leading from the drying and press rooms into the open

With regard to the application of high-tension electric current,[2] electrical appliances of any description must only be installed in such rooms of the factory in which development or entry of coal dust is precluded Electric motors enclosed in special air- and dust tight cases are excluded from this regulation

Inside the rooms of the factory only well-insulated conductors with a water-tight covering are permissible, naked conductors must be laid outside the factory and at a distance of at least 4 metres from the ground The whole of the conductors must be of such sectional area as to be capable of carrying double the normal current without heating more than 50° C above the temperature of the surrounding atmosphere.

Tobacco smoking is prohibited in the rooms of the factory

V PREVENTION OF ACCUMULATIONS OF COAL DUST.

The following orders deal with this subject :—[3]

All working appliances in which drying or dried coal collects, moves forward, or is further treated (drying appliances, elevators, spiral conveyors, rolls, drum sieves, storerooms, press bodies, cooling plants, etc) must be arranged in such a way that the escape of coal dust into the rooms of the factory is prevented.

[1] § 8 of the Halle Bergpolizeiverordnung, Dec. 21, 1903

[2] § 9, *ibid.*

[3] §§ 4 and 16, *ibid.*

All rooms of the factory in which development of coal dust can take place must be provided with exhaust appliances, and the roofs must be provided with tightly fitting safety doors which open outwards.

Fly-wheel pits and other excavations inside these rooms, as well as projecting masonry and beams, must be arranged in such a way that the dust collecting in or on them can be removed quite easily.

The whole of the working appliances serving the purposes of moving and preparing the dried coal, conveying the coal dust, and the housings of the dry elevators and worm conveyors, must be constructed in such a manner that there are no dead angles permitting of the accumulation of coal dust which can remain in one place for prolonged periods.

Flap valves and the like in exhaust flues, channels, and pipes must be arranged so that dust cannot settle on them, and so that they offer as little resistance as possible to the pressure of an explosion.

The installation of storerooms and dry elevators is only permitted under special circumstances (see pp. 123 and 130).

The coal recovered in the coal dust separators must be removed from the press operation or must be compressed as rapidly as possible without being previously introduced into a drier, storeroom, or dry elevator. Stamps must be packed to prevent loss of coal. Coal escaping during compression must be exhausted from the press house and rendered safe, it must not be returned to the operations of pressing. The granular coal dropping from the appliances must be removed or immediately returned to the press stamp. It must be kept separate from the remaining dry coal even up to the charging hopper of the press. The housing of the supply rolls of the press-charging hopper (coffee mill) must be so well ventilated that no dust enters the press house even when the enclosing flap is opened.

The floor of the drying and press house must be sprinkled with water daily. All the rooms in which development of dust occurs must be thoroughly cleansed of dust in all its parts, especially in excavations, at least once every week.

Storerooms for dried coal must be emptied and thoroughly cleansed from dust at least once every week.[1] During interruptions of working, which may probably last 24 hours and longer, the whole of the rooms and appliances containing dried coal must be worked empty.

VI. Precautions and Measures against Spread of Fire[2] and Burning of the Workers.

The following rules are laid down :—

The factory buildings must be made of stone and iron, the roofs must be fireproof and easily closed.

Rooms in which a development of coal dust can occur must be separated

[1] During these operations and the subsequent use of the empty rooms and appliances, much dust may be developed, and as a result the very greatest caution must be exercised.

[2] §§ 3, 6, 16, and 17 of the Halle Bergpolizeiverordnung, Dec. 21, 1903.

from the boiler house or wet-operation shop, if in immediate communication by means of a fireproof wall. Between the drying room and wet preparation shop the wall is necessary up to the level of the coal-supply floor. All the driving gear passing through the wall must be made as dust tight as possible.

The communications between these and the remaining rooms of the factory must be provided with self-closing doors, and all internal or external stairs must be made of stone or iron and provided with iron railings. The whole of the working appliances and their surroundings must, as far as possible, be fireproof, the enclosure of the dry elevator must extend above the factory roof.

On the outbreak of fire the spiral conveyors must be immediately cut off from the elevator by means of slides, flaps, or similar appliances. In the rooms of the factory, easily accessible extinguishers, which can be put into operation quickly, must be arranged in such a way that every part of the factory can be subjected to a stream of water at any time Suitable hose pipes must be at hand. In factories so provided at least one water cock should be placed in the special stair house. The extinguishers should be tested at least once each week.

No buildings in danger of fire and no tipping of glowing ashes must be permitted within a distance of 20 metres from the factory. The conveying and foot bridges leading to the works must be fireproof.

Large quantities of briquettes stored in open or enclosed spaces must be kept at least 20 metres from the drying and press rooms.

Only just the quantities of cleaning and lubricating materials required for the day's use must be allowed in the rooms of the factory, and then they must be stored in fireproof boxes.

Procedure during Fires.[1] —Immediately on the discovery of an outbreak of fire the signal "There is a fire in the factory" must be given in all the shops, by means of a signalling appliance always kept in readiness. Then the whole of the machinery, with the exception of the electric-lighting machine, must be put out of action, the ventilation of the working appliances containing dry coal must be discontinued, and the stop valves between spiral conveyor and elevator closed.

Only if the outbreak cannot be damped by steam, covering with moist pit coal or other suitable means, may it be extinguished by the application of a fine spray of water. (During a fire on one of the steam tables it is best to spray against the lower surface of the table immediately above)

The factory must only be put into operation again when the responsible inspector is convinced that no more glowing coal exists in any of the rooms or working appliances of the factory.

Emergency exits and staircases are to be provided to enable the employees to gain safety in case of fire.[2]

In all the rooms of the factory exits are to be provided in such a manner that the workers can easily get to the outside; from the drying and press rooms at least one exit must communicate directly with the open. If these

[1] § 17 of the Halle Bergpolizeiverordnung, Dec. 21, 1903.

[2] §§ 3, 6, 16, and 17, *ibid.*

rooms are not on the ground floor, at least one staircase, accessible from all the stories, must be provided outside the building. All doors leading to the open must open outwards

These, or other safety regulations of the Prussian mining authorities and those of other German states, which have for the most part been proclaimed in the old mine inspection regulations, have, when conscientiously carried out, proved effective in the course of years and have contributed greatly towards the diminution of the number of coal-dust conflagrations and explosions with their attendant fatal accidents and other dangers. In addition, the freedom of the factory rooms from dust and the safety of working have led to very much better conditions than those prevailing formerly

According to practical experience and the recent researches of Neidhardt and others, the following points are to be observed with reference to the burning of workmen in brown-coal briquette works and their protection:—[1]

1. Uncovered portions of the body are mostly exposed to the action of flames and are burned first and most badly.

2. Superficial fibres, tattered or even torn and very old clothes are dangerous in the event of a sudden fire.

3. Clothing soaked with fat or oil and coal-dust can, under certain circumstances, be used as a protector against the action of flames, but only for a short period of time.

4. For the extinction of an outbreak of fire it is recommended that masks, gloves, and protecting clothes[2] be provided. These must be taken to the place quickly and put on and taken off rapidly

B. DUST-CATCHING APPLIANCES.[3]

I. General.

The separation of the mechanically suspended coal dust from the exhaust of the drier before exit into the open (exhaust or chimney-dust extraction), and the retention of the dust from the rooms of the

[1] S. L. Seeman, "Ueber die Gefahren der Kleidung der Braunkohlenbrikettarbeiter," *Z. Braunkohle*, 1908, vi, No. 50, p. 843. Neidhardt, "Schutzeinrichtungen gegen Verbrennungen in Braunkohlenbrikettfabriken," *ibid.*, 1908, vii, No. 29, figs 233–238

[2] The Gruhlwerk at Bruhl obtains asbestos masks from J. G. Eisel of Griesheim and from C. Schrip of Cologne, jackets of impregnated, non-inflammable material from Honig und Pflug of Cologne. Gloves of leather or other smooth material are suitable after wetting.

[3] Derived from the literature quoted at the bottom of p. 474, particularly from the excellent monograph by Bergmeister Gertner, in addition to other sources.

factory, as well as the further treatment of the dusty exhaust air (internal dust removal), are effected either—

(1) In appliances separated from each other, when the oven spiral is connected directly with the exhaust extractor.

(2) In appliances partially or wholly connected with each other in such a way that the dust stream of the internal extraction meets that of the exhaust extraction, and that in the appliances for the latter the dust exhausted is partially or totally separated.

The exhaust dust extraction and the system indicated under (2) are effected wholly in the dry or wet way (with the aid of water or steam) or in combined dry and wet appliances arranged consecutively. Internal dust removal still, as originally, often consists of a preliminary dry separation of the dust from the air drawn through a steam jet exhauster, followed by a subsequent wet precipitation of the residual dust by the exhauster itself. At the present time more and more of the dust is obtained wholly in the dry way or led to the boiler firing with the exhausted air.

The term "dry" used here and later on in the book is to be understood in the sense that the dust is free from mechanically admixed condensed water vapour, and that its content of moisture is not considerably different from that of the remaining dry coal. It is therefore a dust which can, without disadvantage, be pressed with the dry coal or blown with the exhaust air into the boiler fires.

General Requirements for Dust-catching Appliances.—Above all, every dust extractor must be safe in working, *i.e.* it must be so arranged that dust explosions in the extractor are prevented as much as possible, and any possible sudden outbursts of flame occurring internally or externally can proceed with as little danger as possible. In this respect the safety regulations prescribed for the factory equipment (see p. 481 *et seq.*) apply equally to the dust extractors. According to Gertner, it is particularly desirable to pay attention to the following points:—

Masonry parts must always be kept smooth. Sharp angles should be avoided. Inclines and inclined discharge tubes need not be flatter than 60°. All dust discharge tubes must be so wide that they cannot be stopped up. Points at which friction is developed must be thoroughly attended to. Explosion covers should exist in such number, size, and at such places that possible outbursts are immediately led to the open. The individual parts of the dust extracting plant should be arranged in such a visible and accessible manner that possible conflagrations are soon detected and extinguished without danger. Intimate acquaintance with the appliances by the staff, in addition to continual conscientious attention, are absolutely necessary for good results.

With regard to safety in working, the wet method of dust extraction is undoubtedly superior to the dry method, but this advantage is outweighed by the incomparably greater value of the recovered dry dust, whether it be intended for burning or for return to the operation of pressing. The moist dust obtained from the exhaust vapours can only be applied practically to the latter object, but the dust from the internal dust extraction is utilisable by both methods.

C. Haase, mining director of Meuselwitz, took out a patent for the combustion of dust[1] in which the mixture of coal dust and air is sucked from its source through a high-speed fan and delivered to the steam-boiler furnace. Fig. 198 shows the scheme of the arrangement in section and plan. The mixture is blown over the grate to the fire tube through two branch tubes from the distributing tube V. Each branch tube is controlled by a throttle valve D. A small steam jet *d* controlled by a stop-valve opens into each blast tube to prevent blowing back of the flame into the distributing tube and effects a very intimate mixture of the dusty air with the steam. In this way a non-explosive zone is formed through which no ignition can be transmitted.

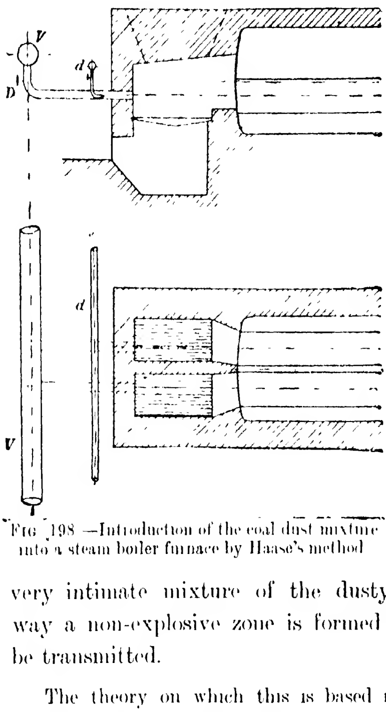


FIG. 198.—Introduction of the coal dust mixture into a steam boiler furnace by Haase's method.

The theory on which this is based is that of the admixture of such a quantity of steam that the dusty air is no longer inflammable, but it is more likely that the combustion can only take place at the higher temperature of the grate. Further, the steam jets must bear a definite relationship to the quantity of dust and the sectional area of the pipes. The application of a fan in addition to the steam jets is necessary, since excess of steam must not be introduced on account of the possible deposition of water on the walls of the pipes, leading to the collection of dust, which grows rapidly and causes fatal stoppages, etc.

[1] *Z. Braunkohle*, 1903, II., No. 29, and 1907, VI., No. 18. See also Gertner's monograph (reprinted), 1908, p. 9 *et seq.*, with diagram 1, representing a plant for burning dust with stepped grate firing.

Haase's method of burning dust has been in operation at the Furst Bismarck mine, Meuselwitz, since the end of 1904, and has since been introduced at the Lauchhammer briquette factory and other works

W. F. Randhahn,[1] as a result of thorough evaporative tests with vacuum measurements, etc., on boilers with and without dust firing, has obtained the following results relating to the efficacy of the Haase method of burning dust:—

(1) Diminution of the grate vacuum with consequent economical combustion. (2) Combustion of the carbon monoxide produced during stoking and more complete combustion of the flue gases (3) No cooling of the flue gases and no appreciable diminution of the boiler output. (4) A considerable economy in fuel as a result of (1) and (2).

The fuel economy is given by Randhahn as 12 7 per cent., but at the Lauchhammer briquette factory[2] the saving is reckoned at about 5 per cent at the outside, and a goodly proportion of heat is rendered useless in warming the excess air in the dusty air to the flue-gas temperature, *i.e.* through about 370° C.

Return of the Dry Dust to the Pressing Operation.—If this is not to affect the quality of the briquettes, the recovered dust must be mixed with the rest of the dry coal as intimately as possible This is rendered difficult by the Halle Bergpolizeiverordnung dealt with above (p. 482), viz the coal recovered in the coal-dust separators must be removed from the press plant or compressed as quickly as possible, etc., but the regulation is amply fulfilled if the dust is led to a worm distributor situated immediately above the charging hopper of the press, or into a special worm running alongside the hopper and discharging into it.

Under "Coal-dust Separators" dealt with in § 15 of the same mine inspection regulations (see p. 175 above) are to be understood all those special appliances which are solely applied to the purification of the exhaust vapours (internal and chimney dust extraction) to such an extent that dangerous results cannot accrue from the blowing about of coal dust.

Utilisation of the Recovered Wet and Moist Dust.—Every fine (over-dried) particle of dust is surrounded by a coating of grease, originating from the bitumen content, which hinders the reabsorption of water. As a result, the particles of dust carried away with the vapours remain dry, which also favours their dry separation. However, condensation of water vapour readily takes place upon them, forming drops of water which trickle through or over the dust. Such a mixture

[1] *Z. Braunkohle*, 1907, No 18, with fig. 156 and five tables

[2] According to a private communication.

of water and dust (moist dust) must therefore be first freed from the excess water before it can be rendered suitable for pressing. Its introduction into the drying appliances, however, would, even when added to the original moist coal, only have the result that a large proportion of the particles would be absorbed from the dry coal by the oven draught, leading to a renewed burden on the dust extractors, while the particles left behind in the coal would undergo a further excessive drying, and possess an increased tendency to ignite On these grounds alone the return of the dust separated in the extractors to the driers, storerooms, or dry elevators is strictly forbidden in the Halle district (§ 16, No. 1, see above, p 482) Naturally, this also applies to wet dust, whose particles become saturated or supersaturated with moisture from the steam jets after destruction of the grease covering

Combustion of moist or wet dust or dust slimes[1] with about 55 to 60 per cent moisture on the general run of stepped grates is unsuitable and not entirely devoid of danger, but on trough grates, however (*e.g* Frankel's system), by observing certain safety measures, it can be carried out usefully and effectually, although the increased amount of ash in the fire tubes, etc, acts disadvantageously and the ejection of flue dust from the fire grate necessitates the installation of a floating ash-catcher

Admixture of the dust slimes with pit moist coal for the preparation of wet compressed stones can only be considered when wet-pressed stones are produced in addition to briquettes. A Scheele[2] recommends the application of the slimes to the moistening of the coal in the mixing trough In case of the recovery of large quantities of slimes, however, only a certain proportion can be dealt with in this way.

Similarly with the use of slimes for the production of porous bricks which can be worked profitably at few works.

Under these circumstances, therefore, the utilisation of wet or moist dust in one or the other direction is limited to individual cases In most cases the slimes are invariably considered a troublesome waste product and given up as lost (further information on pp. 521 to 522), which is to be regretted from the point of view of economy. Consequently, it would be a worthy object to discover generally applicable ways and means for the profitable utilisation of dust slimes, and so long as such methods are not available one is compelled to adopt the much more rational dry extraction in spite of the attendant dangers

[1] Gertner's monograph, pp 17 21, fig 2.
[2] *Z Braunkohle*, 1904, iii p 314

It will now be of advantage to discuss the methods and appliances generally used in practice, first those used for exhaust dust extraction and then those for the internal dust extraction.

II. Methods and Appliances for Exhaust Dust Extraction.

1. *General Review.*

The particles of dust in the exhaust vapours are for the most part caused to settle dry by an enlargement of the sectional area of the exhaust channel, or more generally by the attachment of a dust chamber in which the velocity of the vapour is diminished. Further, by means of suitable shapes and dimensions of the dust chamber an endeavour is made to cause the gas to change its direction (see fig. 155, p. 413) and impinge against surfaces on its way to the open, causing it alternately to rise rapidly and fall slowly. However, this principle must not be carried too far, for as a result of the numerous resistances the suction of the exhaust chimney would be unfavourably affected, with disastrous effects on the output of the drier. In addition, it would be very difficult to remove the whole of the dust from the exhaust.

This method, therefore, needs a supplementary process which usually consists of a precipitation of the residual dust (the finest particles of dust) by spraying with water in special spraying chambers. Since, as remarked above, the dust particles can only take up water after destruction of the greasy covering, a satisfactory result can only be obtained with a very fine, powerful spray of water.

Spray Nozzles.—Instead of the inadequate simple sprinklers it is now the practice to use spray nozzles, from which the water is ejected under a pressure of as much as three atmospheres. It must be distributed as a fine mist over the whole area of the sprinkling chamber. If necessary, therefore, several jets must be arranged next to or above each other.

Of the usual types of nozzles, conical and spiral nozzles are only effective with clear water; they soon become stopped up with dirty water. On the other hand, the Lechler spray nozzles, devised by Paul Lechler of Stuttgart, have proved effective even with dirty water. They are supplied in two designs. The so-called Lechler fluid dust-destroying nozzle (fig. 199) sprays at right angles to the water pipe, while the centrifugal nozzle (fig. 200) sprinkles in the direction of the pipe itself. The water flows tangentially into a cylindrical drum and receives a rotatory motion. A drilled mouthpiece is screwed into the bottom of the drum. The liquid dust-destroying nozzle, with a drum

diameter of 50 mm. and a hole of 6–8 mm. diameter in the mouthpiece, is best adapted for the removal of dust from exhaust vapours (price 16·50 marks, mouthpiece 3 marks). Further information is given below on the method of fixing in the exhaust flue.

The application of steam instead of water would be more effective, since it grips the dust and causes it to settle better, but is too expensive on account of the large amount of steam used. Consequently, steam nozzles are seldom used, and then principally for the invigoration of the flue draught.

Further, revolving jets with internal wet deposition of dust and

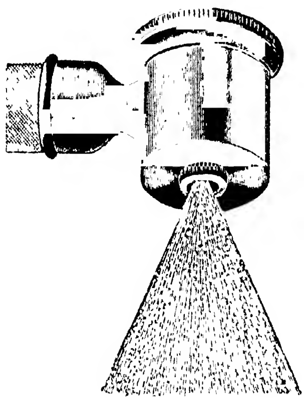


FIG. 199.—Lechler's liquid dust destroying sprinkler.

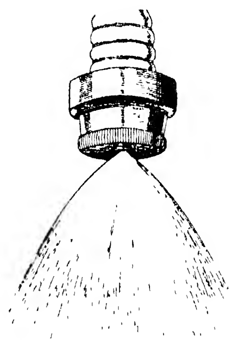


FIG. 200.—Lechler's centrifugal sprayer.

slime separators (Sichtig, Simon, Buhler and Baumann systems) are also used for the wet method of dust extracting.

The remaining ways and means for the extraction of dust from exhaust vapours require as dry a recovery as possible even of the very finest dust, and are carried out—

(1) Either by subjecting the vapours to a centrifugal action (Boreas method, Scheibe system, Michaelis method);

(2) Or by filtering through the coal in the drier (Gruhl system) or through a cloth filter (Beth system).

2. *Prevention of Dust Development in the Driers.*

Whether the dust extraction of the exhaust from the drier is carried out by one method or the other, it is a wise plan to take care that as little dust as possible is carried away in the exhaust in every case. This

Outfall Caps.—It has already been indicated on p 412 that the mouths of the lower tubes of tube driers are provided with outfall caps inserted in such a way that the tubes can only discharge dry coal when the caps reach their lowest positions during the rotation of the drum, thus providing the least possible height of fall. This is at a minimum in the tubes of the outer circles.

The outfall cap of the Maschinenfabrik Buckau, which was formerly most generally used, grips the mouth of the tube with its sprung sheet iron neck and carries the coal through a radial or sector shaped section cut in a strip of sheet metal soldered on to the front Discharge takes place when the opening is directed downwards in its lowest position. But the loose portions of the metal strips bend very easily, and then allow coal to be discharged before the proper time. Further disadvantages are · throttling of the exhaust, retention of lumps of balled up soft coal which may lead to conflagrations, and further the control of the drier is made more difficult.

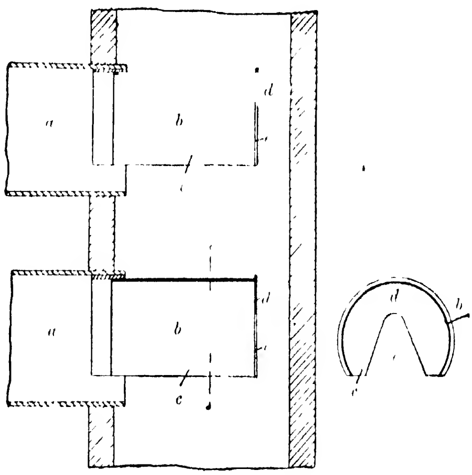


FIG. 201.—W. Forster's outfall caps for tube driers

The outfall cap designed by W. Forster,[1] works manager of the Senftenberg II, is represented in longitudinal section in fig 201, a front view being given to the left. In each tube mouth *a* is fixed a cap *b* having a side slit *c* along its whole length, while the soldered front piece *d* is cut away to allow for inspection of the contents of the tube. Vapours escape through the slit *c*, which is directed either sideways or upwards during the rotation of the drum.

A later type of the Forster outfall cap is provided with a screw thread-shaped front portion with a suitable metal strip and a discharge plate in the longitudinal axis of the cap equal in height to the depth of the thread.[2]

The "Reform" cap, designed by H. Franz, manager of the Gotthold pit, Lower Lausitz, consists of an enlarged worm-shaped container with a beak-shaped outfall (fig. 202) clamped into the tube by a short neck. In front is a circular hole whose diameter is only slightly less than that of the tube.

[1] *Z. Braunkohle*, 1905, iii., No. 9, p. 119, figs 52 and 53

[2] *Ibid.*, 1908, vi., No. 42, pp. 716 717, fig. 286

In these and other similar caps the defects of the Buckau caps appear to be partially overcome, but at the same time they do not completely attain their object.

With a view to the prevention of the development of dust during discharge from the tube driers A. Scheele and Gertner advise the use of a fore chamber into which the coal can fall while the vapours continue in an approximately horizontal direction to the main chamber, where they commence their ascent.

A further very effective arrangement consists in the isolation of the oven or collecting worm, which often whirls up much dust, from its connection with the flue draught. In some installations this is attained by means of a discharging flap counterbalanced by a variable weight. The flap takes up the coal from the tube drier until the counter-weight is exceeded, when the flap falls and allows the coal to slide into the oven worm, after which it is immediately closed by the fall of the counter-weight. The mechanically driven double-flap closing of the Maschinenfabrik Buckau is still more certain in operation.

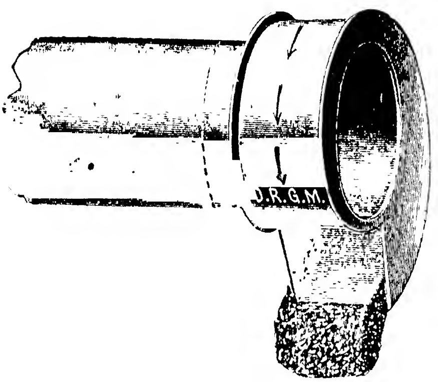


FIG. 202.—H. Franz's "Reform" outfall cap for tube driers.

Gertner[1] proposes another method of attaining the same object by means of two positively moved slides of which the upper one is opened while the lower one is closed, and *vice versa*.

In addition to this, it is, according to Gertner, highly desirable to provide the oven worm with a special draught which also provides for the removal of vapour from the moving coal and prevents the deleterious results accruing from condensation.

It has already been pointed out (p. 474) that the development of dust is considerably less in the steam table drier than in the tube driers, mainly because of the timely sieving and removal of the fine material. However, the attendant worm conveyor is a source of considerable dust, and should not therefore, as is usually the case,

[1] Monograph, p. 33.

have an outlet into the drying oven and communicate with the exhaust dust extractor, but should rather be connected with the internal dust extractor.[*]

In the table driers themselves the development of dust can be readily diminished by the provision of inclined slides or downcomers below the discharge openings in the various tables in accordance with the suggestions of W. Gertner.[1] Table ovens with inclined downcomers have already been in use for some years at the Grube Robert briquette factory, Wansleben, which is described in Section X.

III. Examples of Dust Extraction from the Exhaust.

1. *Dust Removal by Centrifugal Force.*

(*a*) *The Boreas Method* (fig. 203).—This method introduced shortly after 1890 by the Maschinenfabrik Buckau, and then further developed by Hoddick & Rothe, Weiszenfals,[2] and other firms, is here illustrated in its modern application to tube driers.

The exhaust is sucked off by a fan and blown tangentially into the top of a cylindrical chamber called the Boreas (see plan below) in such a manner that the particles of dust are forced against the walls and loosely adhere until on accumulation they fall, by virtue of their own weight, into the collecting and discharge hopper at the bottom of the chamber.

Whilst in the older Boreas the exhaust gases circulate round the wall in spiral fashion towards the lower opening consisting of a wide exhaust tube hanging centrally from the bottom of the chamber, in the Boreas illustrated in fig. 203, which possesses two additional internal cylinders, the vapours are caused to fall and rise alternately in the direction of the arrows. In this way a more complete removal of dust is effected. According to Gertner,[3] such a Boreas for two small tube driers has collected about 50 hl. (or 50 × 50 = 2508 kg.) of dust in twenty-four hours from a Lower Lausitz soft coal (Wilhelminensglück pit at Clettwitz). Compared with the older Boreas without the central tubes, this is about double the yield, but it is true that the output of dry coal was about 2·6 tons higher in the later tests. But even with the cylinders a sufficiently effective action cannot be

[1] Monograph, p. 36. See also *Z. f. Berg-, H.- u. Sal-Wesen i. Pr. St.*, 1908, vol. lvi. p. 186.

[2] Among others, this firm erected the Boreas plant at the Glückauf pit in Lichtenau, Silesia.

[3] Monograph, pp. 39–40.

attained, and consequently the vapours are led into an auxiliary chamber (fig. 203), where they are further purified by steam from a Korting nozzle.

In the Boreas, in order to recover the dry dust suitable for pressing, and to prevent therefore the condensation of steam, the walls must be well insulated. Chambers of galvanised iron are protected by a layer of infusorial earth or similar material, while in brickwork chambers air cushions are provided.

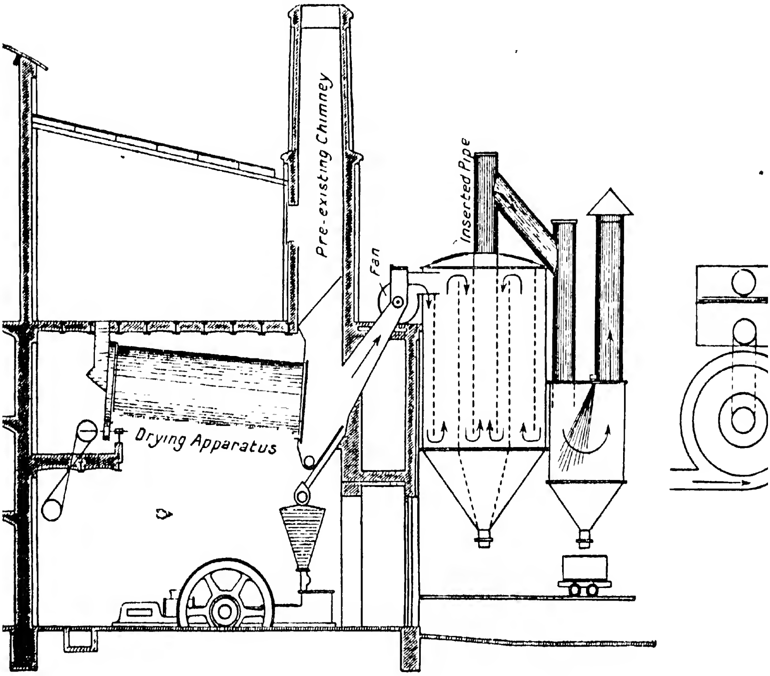


FIG. 203.—Extraction of dust from the exhaust by the improved Boreas method. Combined dry and wet process by means of steam. Scale = 1 · 200 (Gertner).

The precipitation of the fine dust issuing from the Boreas chamber with the exhaust is effected much more completely by the sprinkling method of Emonds,[1] engineer of the Berggeist briquette factory at Badorf.

The exhausts from each pair of Boreas chambers pass on to a square sprinkling shaft, constructed of galvanised iron, where they pass through several chambers provided at the bottom with wire netting inclined at 45°. The wire nettings, which have holes of 20, 16, and 12 mm. and are arranged one above the other, are each subjected to

[1] Gertner's monograph, pp. 40-41.

the action of a spray nozzle supplying water under a pressure of 3 atms. At the top the vapours have to pass a constricted portion provided with horizontal wire netting with 8-mm. holes, sprinkled with a fine drizzle from two spray nozzles, and ultimately the gases passing into the open contain only an inappreciable amount of dust. The moistened dust particles remain hanging to the meshes of wire sieve until they are removed by the pressure of the water and washed into a container below.

At the Berggeist briquette factory, with 8 small and 4 large tube driers, with a total heating surface of 5180 sq metres, each set of 4 driers is provided with 2 Boreas and 1 Emond's dust extractor, 3 tons of dust (containing about 20 per cent. water), suitable for pressing, are obtained from each pair of Boreas chambers, and 12 tons of dust (with 55 per cent. water) from the auxiliary sprinkling shaft are recovered every 24 hours from what was formerly looked upon as waste. There are eight centrifugal nozzles in every 2 sprinkling shafts, utilising 12 cubic metres of water in 24 hours, a yearly use of 86,400 cubic metres for the whole installation.

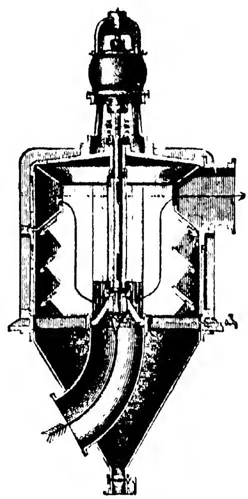


FIG. 204 – Centrifugal separator for the dry extraction of dust from exhaust vapours R. Scheibe & Sohne, Leipzig

The working costs per 24 hours of the complete dust extraction according to Baldus[1] amount to 5·7 marks for the sprinkling water, 6·5 marks for its elevation, and 1·4 marks for liquidation and interest—a total of 13·60 marks, equal to 4 pf. per ton of briquettes with an output of 350 tons.

(b) *Dry Dust Extraction.*—R. Scheibe & Sohne, Leipzig (fig. 204). The process is similar in principle to the same firm's method of oil extraction from waste steam already described. The vapours, which are simply to be extracted dry, are driven through a jacketed fly-wheel (with upper belt drive) in the direction indicated by the large arrow.

Rapid rotation of the fly-wheel gives a far greater centrifugal force to the dust particles than to the moist air.[2] Therefore the dust particles are driven to the inner surface of the jacket, the re-entrant and salient angles of which break up the centrifugal force into its two components, so that the dust particles pass through the slits provided in the salient

1 *Z. Gluckauf*, Essen, 1908, No 50, p. 1762.

2 According to the specific gravities which under these conditions = 0·8 : 250 : 1000 for moist air, dust and drops of water calculated to cb. dm. 1 grm

angles into the space surrounding the fly-wheel in the direction indicated by the small arrows. The dust separated from the exhaust slides into the hopper

The first plant on a working scale was erected at the Wahlitz briquette factory of the Weischen-Weiszenfelser Braunkohlen Akt. Ges , Halle.

(c) *The Centrifugal Dry Dust Extractor* of K Michaelis, a civil engineer of Cologne, describes 250 to 300 revs. per minute on a horizontal axis, while the exhaust enters on both sides of a tubular jacket

Ribbed conducting shovels inclined to the axle lead the centrifugalised particles of dust through slots, while the dust-free vapour is sucked off from the interior by means of an exhauster

The power required is about 5 H.P for the separator and exhauster of each tube drier ; the amount of dust separated in 24 hours is 1000 kg , containing 8 to 10 per cent. water. The dust extractor tested at the Wilhelmina briquette factory, Frechen, shortly afterwards found application in the Hurthenberg factory at Hermulheim and the Luise factory at Bruggen.

(d) *Wet Dust Extraction.* Oskar Sichtig & Co., Karlsruhe (Baden). — A centrifugal water spray (legally protected) whose speed of rotation is arranged so as to produce only a slight vacuum, draws in the exhaust, mixes it with the water, and forces the mixture through a delivery pipe into a separator (Cyclone or Boreas), where the particles of dust and water are driven to the walls by centrifugal force Only purified moist air issues from the outlet, while the slime flows from the hopper.

The method can, as already described, be applied as a simple wet, or a combined wet and dry process. In the latter case the vapours are first drawn into a dry separator by means of a jet and caused to yield up as much dust for pressing as possible.

The methods approved of in the last few years were soon applied at the Senftenberg works of the Cons. Halleschen Pfannerschaft, and later at the Bitterfeld brown-coal briquette factory of A. Ackermann & Co , for both exhaust and internal dust extraction. In addition, the methods were applied for internal extraction alone at the Marie pit in Deuben, near Zeitz (Riebeckshe Montanwerke Akt. Ges.).

(e) *Wet Extraction* by Simon, Buhler & Baumann, Frankfort a. M., is effected by means of an exhauster with a tubular sprinkler and a ribbed pulveriser revolving rapidly with the vane wheel, combined with a separator provided with inclined deflecting walls. The method

is applied at the Gruhlwerk, near Bruhl among other places. Experiments on the dry extraction are in progress.

2. *Dust Extraction without Centrifugal Force, combined dry (by means of baffle walls) and wet (with the aid of water jets).*

(*a*) *Dust Extractors for Tube Driers.*—The Buckau method of dust extraction illustrated in fig. 205 conforms in both sections to the requirements laid down above (pp. 489 to 490), and is self-evident from the sections and plan. Separation of the heavier dust particles in the smooth cemented vertical dust chambers of the first section is considerably facilitated by the varied section of the chambers for the rise and fall of the stream of exhaust vapours.

The dry dust sinking to the bottom of the first chamber is conveyed to the presses, the moist and wet dust is converted into mud with the water issuing from the sprinklers under a pressure of 3 atms.

By the use of a sufficient quantity of water and with a correct regulation of draught a completely satisfactory and effective purification of the exhaust is effected without influencing the output of the drier. However, the disadvantages bound up with water sprinkling must be taken into account but in spite of this, the system has found widespread use.

In the form represented in fig. 205, or some similar design, the system finds application at the briquette factories of the Rhenish Liblar and Donatus pits at Liblar, Graf Furstenberg at Bottenbroich, Carl pit at Frechen, in the Lower Lausitz pits Eva, Renate, Anna Mathilde, belonging to the Akt.-Ges. Ilse, and others. According to experiments made by Gertner, the following amounts of dust were obtained in a year from an installation of eight tube driers.—

1. Dry dust 2880 tons = 0·5 ton per annum per sq. metre of heating surface from the exhaust and internal dust extraction (exclusive of the dust accumulated by the Beth filter).

2. Wet dust. 4000 tons = 0·7 ton per sq. metre of heating surface. Each drier requires four channel sprinkling jets each requiring 12 cubic metres of water in 24 hours; the total annual consumption of water being $8 \times 4 \times 12 \times 300 = 115{,}200$ cubic metres. The temperature of the mud slimes is about 65° C.

In the appliance of the Bernburg Maschinenfabrik the necessary changes of section and changes of direction are obtained in chambers arranged one above the other rather than in chambers arranged next to each other. The final sprinkling with water is effected by means of centrifugal nozzles or atomising sprinklers (see p. 490, fig. 199). At the Wachtberg pit, near Frechen, the whole appliance has proved to be very

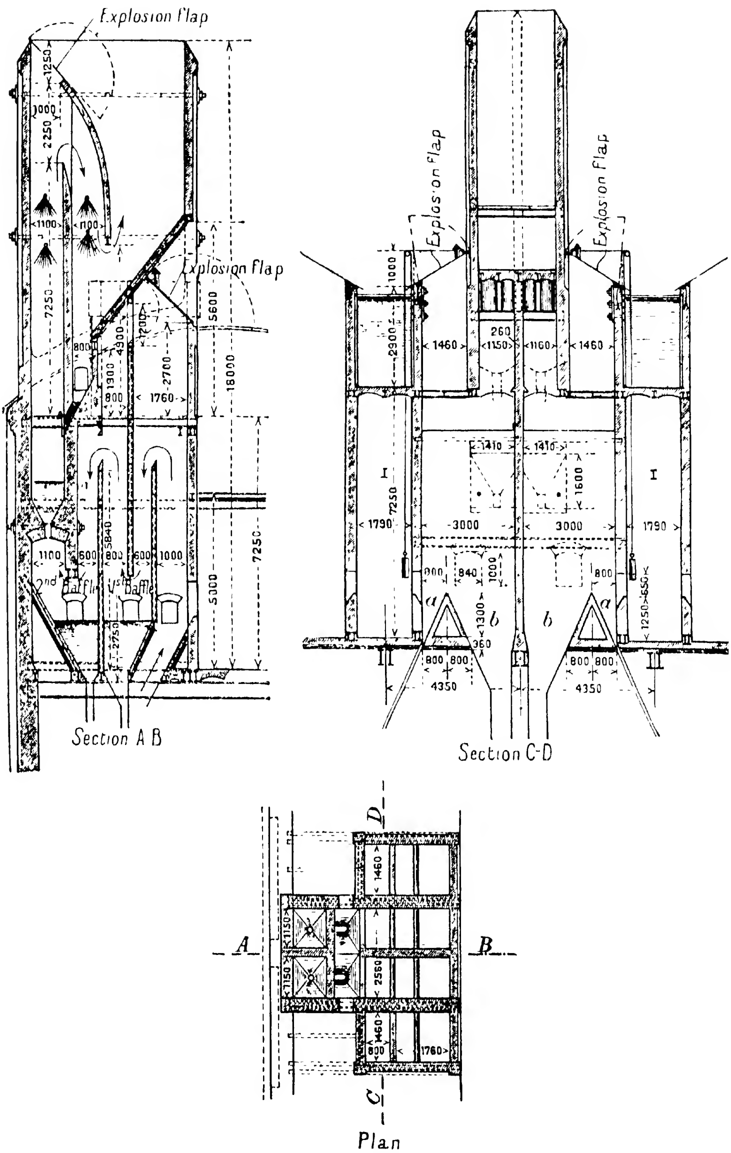


FIG. 205. Buckau plant for dust extraction from the exhaust (combined wet and dry) for tube driers. Scale = 1 : 200 (Gertner).

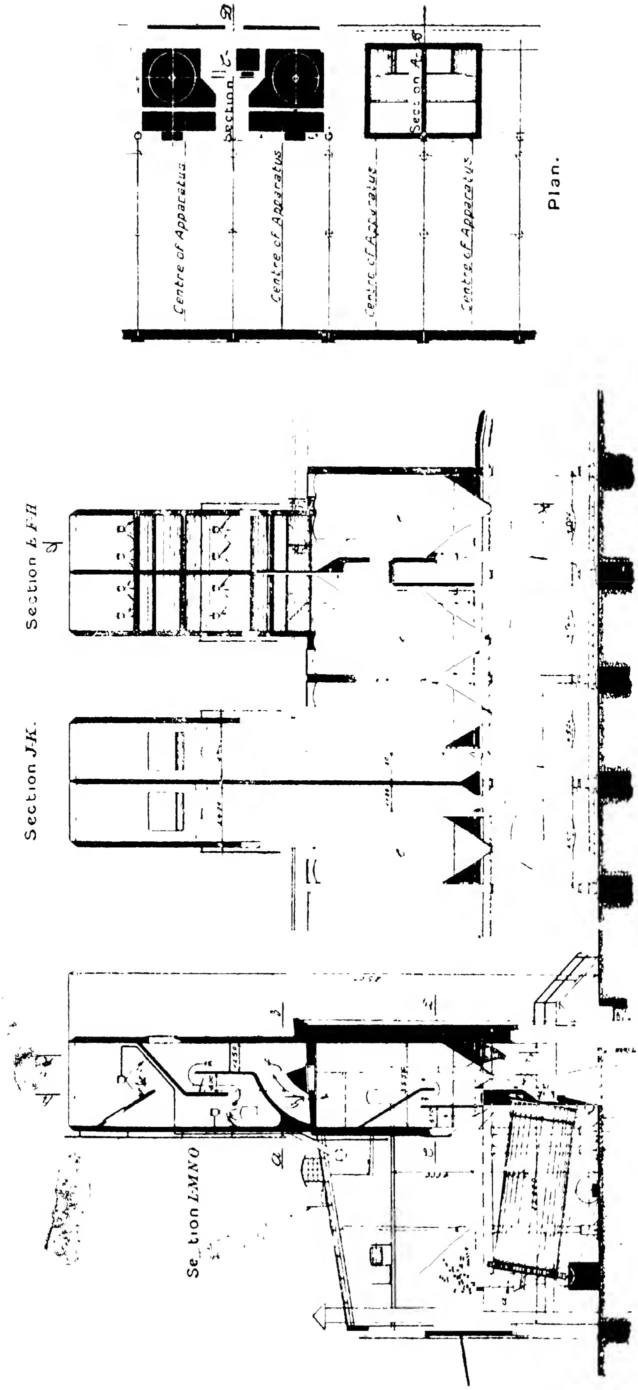


FIG 206 —Bernburg appliance with Lehle's spray nozzles for dust extraction from the exhaust.

efficient and certain in operation. The slime water can be pumped to the nozzles after a certain amount of purification in a clear settling tank.

(*b*) *Dust-catchers for Table Driers.*—It is quite clear that only the lower table produces dry dust and requires a dust extractor.

In the dust-catcher represented in fig. 207 the vapours rise from the upper table into the first part of the chimney, and thence directly

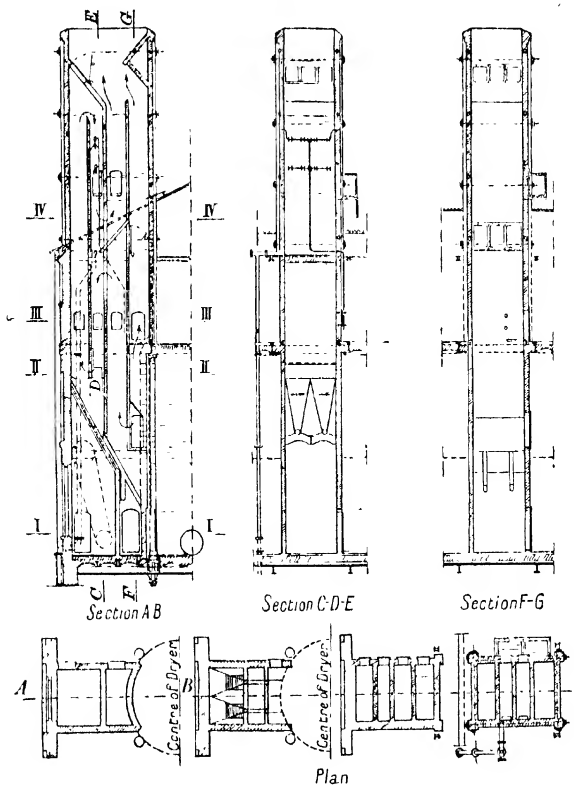


Fig. 207 —Zeitz dust catcher (combined dry and wet) for table driers. Scale = 1 : 300 (Gertner).

into the open, while the dusty exhaust from the lower table is first drawn into the second section of the chimney and is then drawn alternately up and down through the remaining chambers in the direction indicated by the arrows The dust retained in the chambers is quite suitable for pressing so long as it does not enter the sphere of action of the spray nozzles and no condensation takes place. It is then returned to the bottom table of the drier in the manner indicated in fig. 207. In all other cases the recovered particles of coal must not be used in pressing.

3. *Extraction of Dust from Exhaust in the Pure Wet Way.*

At the Clarenberg pit, Frechen, a plant originally intended for dust extraction from eight small tube driers in the dry way gave unsatisfactory results and has been converted into a pure wet-extraction plant by the addition of water spray nozzles acting in the direction of the exhaust current According to Gertner, who has described this plant more completely,[1] apart from the great safety attained in working, the appliance in its present form still leaves much to be desired in the way of efficiency

The annual consumption of water of the eight jets amounts to 13,200 cubic metres. About 5000 tons of slimes, containing about 55 per cent water, are separated in a year from the muddy liquors steadily flowing away, at a temperature of 65° C The slimes are not utilised.

4. *Dust Extraction without the Use of Water Gravitation Process for Table Driers.*

At the Victoria pit, Groszraschen,[2] the oven chimney of each table drier is divided into two sections by means of a dividing wall extending to the height of a sheet-iron cover at the top. The dust-impregnated exhaust from the tables enters below the cover plate and passes through the first section into a dust chamber surrounding the chimney, where the dust separates in consequence of the sudden change of direction, while the dust-free vapours pass into the second section and are drawn away at the top.

The amount of dust separated from a 29 step table drier in 24 hours is given as 3 hl The dust passes through chutes into a worm conveyor. Certain defects exist in the method

(*a*) *For Tube Driers.*—A method of dry dust extraction on the effective principle of the Schumann flue dust-catcher is in operation at the Bleibtren pit (Gruhlwerk) at Kierberg.[3] The flue dust-catcher of the Zeitzer Dampfkesselfabrik und Apparatebauanstalt G. Schumann of Zeitz (fig. 208, *d*) splits up the stream of gases by means of a number of peculiarly arranged cast-iron elements standing vertically in an enlargement of the main smoke channel, into a number of small streams from which the particles of ashes are separated as a result of the sudden changes in direction.

[1] Monograph, pp 53-54, fig. 24 [2] *Ibid*, pp 54-55, fig. 25
[3] *Ibid.*, p. 55 *et seq.*, fig. 26, and *Z Braunkohle*, 1904, m., p. 600 *et seq.*

The bow-shaped portions *a* lead the gases from *d* between the individual elements; the sharp cornered portions *b* deflect them at right angles across *c* towards *e*. The heavy suspended particles of ash or soot are driven into the cross-hatched angular space *c*, where they settle and ultimately succeed to a collecting hopper at the bottom of the flue which is emptied from time to time. Each catcher can be revolved about an axis *f* and can be adjusted like a venetian blind. As a rule, two series of catchers are arranged.

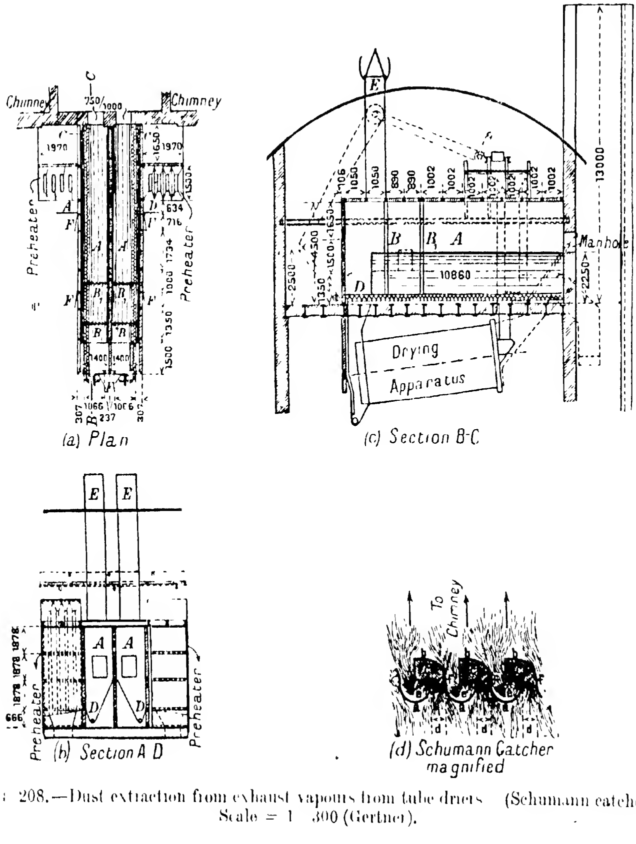


FIG. 208.—Dust extraction from exhaust vapours from tube driers (Schumann catcher.) Scale = 1 : 300 (Gertner).

The application of the catchers for the extraction of dust from exhaust vapour can be seen from fig. 208, *a* to *c*. The vapours from each tube drier issue into an elongated chamber A with two series of catchers B and B_1, and then stream into the exhaust flue through a third series of catchers C arranged sideways at the end of the chamber. A worm conveyor is provided in the wedge-shaped bottom of the chamber A for the removal of the precipitated dust.

With the object of utilising the heat of the purified vapours for

preheating the crude briquetting coal, the three series of catchers are situated between the preheating bin and the chamber

The preheater[1] consists of a system of double-walled chambers above the inlet side of the tube drier. Before charging, the coal is led into one end of the system and, meeting the vapours led in at the other end, becomes preheated Explosion tubes E leading to the open serve to deal with possible explosions, and under certain conditions openings F, fitted with doors which easily open outwards, are provided

According to Gertner[2] the separation of dust was not quite perfect, and the works management was not inclined to add a small sprinkler.

From a large tube drier with about 710 sq metres of heating surface about 1000 kg of dust were recovered for the pressing operation in 24 hours. The counteracting series of catchers did not appreciably affect the draught.

(*b*) The Gewerkschaft Roddergrube of Bruhl[3] have recently taken to separating the dust partly dry in a large chamber with baffle walls, and partly wet by condensing the steam in channels provided with roof-shaped sliding surfaces, between the series of which the cold moist briquetting coal is allowed to slide downwards in a zigzag fashion At the same time the coal becomes preheated (see p 368)

5 *Dust Extraction in a Factory with Tube and Table Driers arranged consecutively*

The exhaust from the tube driers is simply treated gravitationally and the table drier exhaust is centrifugalised Combined methods are also employed

The arrangement is illustrated and fully described in Section X along with the description of the complete briquetting plant of the Robert mine.

6 *Filtration of the Dust from the Exhaust Vapours*

(*a*) *Counter-Current System* (1) *For Tube Driers* The removal of the exhaust on the system of counter currents which is applied at a number of Rhenish works has already been indicated on p. 412.

Counter currents were first applied at Bruhl in the latter part of 1890, and in 1908 a total of 212 appliances of this type were applied to 73 tube driers in the district formerly known as Bruhl-Unkel.

If the air passing through the drier, together with the moisture and the dust taken up, move in the opposite direction to the coal the

[1] *Z. Braunkohle*, 1906, v., p 429 *et seq* [2] Monograph, p 57

[3] *Z. Braunkohle*, 1908, vii, No 27, pp 461 465, figs 229 232.

greater proportion of particles of dust adhere to the moist grains of coal so tenaciously that they are carried along and discharged at the bottom. The coal therefore acts as a filter, and this is particularly so when turning shovels are used.

The counter current dried coal exhibits a peculiar foaming appearance which looks dull in bulk, while the coal dried in an appliance in which the currents are in the same direction has a smoother surface and a somewhat lighter colour.

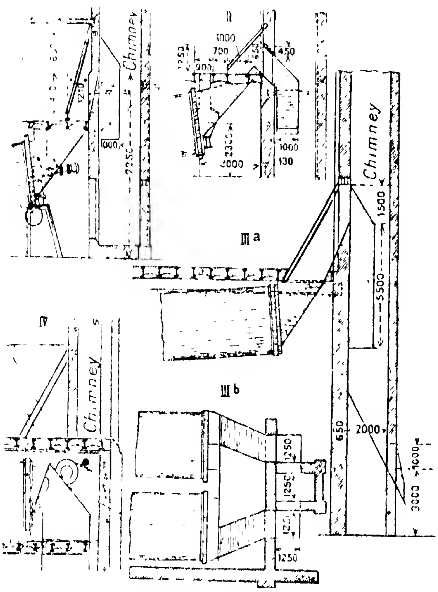


FIG. 209. Counter-current dust extractor for tube driers. Scale = 1 : 300 (Gertner).

Particles of dust, not retained or given up again to the gases, pass away at the inlet side of the drier and require a special separator. For this purpose an enlarged space situated between the drier and the exhaust flue is provided. It usually consists of an accessible sheet-iron chamber whose bottom slopes steeply towards the front wall of the drier so that the precipitated coal can slide back again. The exhaust can be conveniently deviated to the flue at this point. Fig. 209 shows several examples. A large or small quantity of dust—according to the position of the deviating pipe—is separated in the lower portion of the flue, drawn off in tipping waggons, and conveyed to the moulds. The dust contains about 40 per cent. water.

(a) At an installation equipped with 18 tube driers (each of about 710 sq. metres heating surface) connected in pairs to exhaust flues, and in which groups of 8, 4, and 6 driers had been connected as in I., II., III.*a*, and III.*b* (fig. 209) respectively, the amount of dust obtained in a particular case was:—

I.	150 kg.	from 1 flue	=	600 kg.	from 4	flues	in 24	hours.
II.	150	,, ,,	=	300	,, 2	,,	,,	,,
III.	100	,, ,,	=	300	,, 3	,,	,,	,,
Total	100	,, ,, 3 flues	=	1200	,, 9	,,	,,	,,
			=	360 tons	from 9	flues	per year.	

(*b*) At a plant with 12 tube driers (each of 668 sq. metres heating surface, with a connection as shown in IV. (fig. 209), a daily total of 8400 kg. dust, equal to 2500 tons per year, was obtained, a quantity which is incomparably greater than in case (*a*). It is necessary therefore to arrange the appliance in such a way that the bulk of the dust is separated and returned to the drier before the gases reach the chimney flue.

As a result of more than ten years' working experience at the Gruhlwerk, there is no doubt that a perfectly arranged counter-current dust extraction provides the greatest safeguard against common dangers However, the system shows an unavoidable disadvantage in reducing the output of the drier, caused partly by the air resistance in the drying tubes, but mainly by the condensation of water vapours in the coal and the necessary re-evaporation of the resulting increase of moisture. Under otherwise exactly similar conditions the diminution of output of dry coal, compared with ovens in which the currents flow in the same direction, amounts to at least 15 per cent Further, conflagrations may take place very easily owing to balling up of the coal and stoppages in the tubes, and also as a result of dust in the chambers, particularly during the suspension of operations These dangers, however, can be successfully coped with by careful attention.

In the case of Table Driers. Dust Extraction by means of Intermediate Plates.[1]—In this method, which is widely applied in Rhenish briquette factories, the oven structure is divided by a strong intermediate layer of concrete situated just above the sieve table. The exhaust flue rises from the upper space and, as a result, fresh air is drawn into the lower space below the tables, passes up the shaft-like opening in the middle of the drier over the cool moist coal on the upper tables, and finally escapes into the flue. In this way the coal takes up and retains as much dust as possible, but the method is naturally not nearly so effective as in the case of tube driers.

The bulk of the dust passes along with the vapours into the upper space and settles on the intermediate floor. Under such circumstances, with the temperature at this point ruling at about 60° C., the attention of the upper portion of the oven is deleterious to health. Consequently, intermediate walls have been introduced which, however, only allow one quarter of the oven to be inspected at once.

The dust collecting along with the condensate is of no value; it is usually removed once a week (on Sunday) and tipped on to the heap.

In an installation of six ovens each with 32 tables, 528 sq. metres heating surface, and a cubical content of the upper space of 225 cubic metres, 1·7 tons per 24 hours, equal to 510 tons yearly, of moist dust were obtained. Another installation of four similar ovens and a cubic capacity of 136 cubic metres gave 0·4 ton per day, or 120 tons per year. Per year and per sq.

[1] Gertner's monograph, p. 64.

metre of heating surface a yield of 0·16 ton and 0·06 ton were obtained respectively, a proof of the influence of the size of the chambers The decrease in the output of the oven owing to the intermediate floor amounts to about 5 per cent. The system has proved itself safe in operation, but is nevertheless very incomplete

(*b*) *Filtration through Fabrics*.—After the purification of dusty air by means of suitable cloth filters—especially by the system of the W. L. F. Beth Maschinenfabrik in Lubeck—had given satisfaction in many branches of industry, this method of dust extraction has been introduced into brown-coal briquetting in the past ten years, first at the Horrem briquette factory (Rhineland), for internal dust extraction. Since then it has been more widely applied in Rhenish and other districts and has also been used for the extraction of dust from exhaust vapours

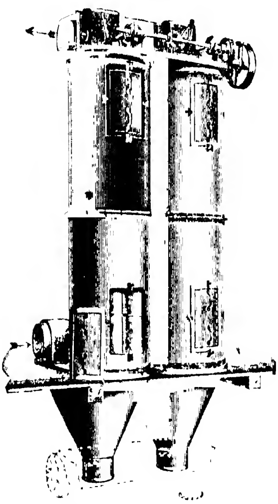


FIG. 210.—Pair of Beth dust filters External view.

In more recent years cloth filters of the firm of Simon Buhler & Baumann, of Frankfort a. M, have been introduced into brown-coal briquette factories, especially those of the Rhenish district

In principle the Beth filters, or tubular suction dust collectors, Beth system, Lubeck (figs 210 and 211), are arranged as follows —

A number of slightly conical cloth filter bags *b* are arranged in an iron cylinder *a*, so that their open lower ends are fastened to corresponding low columns in the base *c*, while the upper, closed ends are suspended from the cover *d* by means of the common frame *e*. From the flue *f* running along the back of a whole series of filters, the dusty air is sucked uniformly from below into the filter cloths (right of fig. 211) with the aid of a valve (not shown in the diagram) communicating with the upper suction channel *i* The cloths keep back the dust, while the purified air passes through the pores of the material and rises towards the opening *g* in the roof of the cylinder into the channel *i* and is blown through the valve into the open.

From time to time (usually every five minutes) the accumulated dust is removed from the filter by means of the reversing and shaking appliance arranged on the top of the filter. First, the inclined rotary

valve q is turned in the sheet-iron cover h into the position indicated in the top left-hand corner of fig 211, so that the suction effect is cut off from this cylinder and atmospheric air enters through the openings s and g. This incoming counter current of air, which varies in strength according to the pre-existing vacuum and the size of the inlet, which can be varied at will, makes its way through the cloths a from the out-

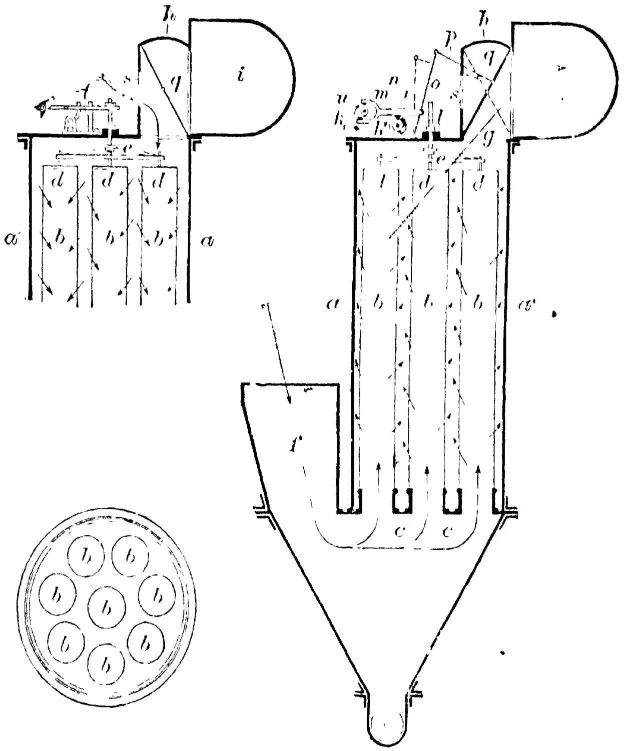


FIG 211.—Sectional diagrams of a dust filter, Beth system (According to Gerther)

side to the inside and removes the dust internally At the same time, the loosely hanging cloths b are drawn tight from above and allowed to fall again. This usually happens seven times in rapid succession, so that the dust is shaken from the interior of the cloth, falls into a collecting hopper below, and is led away by means of a common spiral conveyor running the whole length of the series of filters. After the last shaking the valve q is returned to its original position (fig 211, right), the entrance of atmospheric air is cut off, and the cylinder is again put into communication with the suction action of the fan

The reversing and shaking appliances work as follows.—The shafts k and k_1 are caused to revolve rapidly in opposite directions. k carries the operating wheel l, consisting of a round disc with a groove cut in the greatest portion of its circumference guiding the projection of the operating lever n. The lever is connected with the valve q by the bars o and p. As soon as the ungrooved portion r of the operating wheel l engages with the projection n, the lever is raised and can glide along the wheel actuated by the cam m on the shaft k_1, engaging with the projection in the forked end of the lever. In this way the lever n with the links o and p are drawn back and the valve is reversed.

In order to shake the bags, the operating lever is connected with a lever t whose forked front end is coupled with the bar of the frame e. On drawing back the lever n, the lever t also recedes (left of fig. 211), when its rear end comes within the sphere of action of the cams on the shaft k_1. In this way a reciprocating motion is communicated to the frame e and the loose cloth is alternately drawn tight and allowed to fall free again.

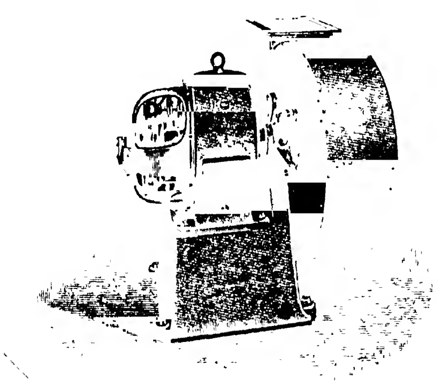


FIG. 212.—Beth exhauster with electric motor.

By means of the other cams and the continued revolution of the shaft k_1 the shaking during admission of air is continued until the operating wheel l has revolved so that the projection on the lever n again engages with the groove. In this position the groove is somewhat deeper, the lever n assumes its lowest position, the projection n in the fork enters the circle of action of the cam shaft, which pushes the lever n into its original position and reverses the valve q.

The cleansing of the various cylinders of a series of filters is effected in a definite order so as not to interfere with the suction of the system. The power consumed by the crank shaft amounts to $\frac{1}{10}$ H.P. at a maximum; that consumed by the exhauster (fig. 212) varies according to the size of the plant.

Dimensions and Properties of the Filter Bags.—Formerly bags of 320 mm. diameter at the top and 400 mm. diameter at the bottom were employed, but recently bags of 150 to 200 mm. diameter have been preferred, since the filtering surface is largely increased by correspondingly increasing the number of bags. According to local conditions the height varies up to 3 m. Everything depends upon the proper treatment and nature of the cloth, which was formerly woollen

but is now made of a mixture of linen and wool. Even the best bags ultimately become impenetrable. After removal they can generally be restored to utility by beating, but every care must be taken to prevent damage. Washing utterly ruins the material.

During the extraction of dust from exhaust vapours they must be passed through the filter at such a temperature that no condensation takes place, otherwise the material gets stopped up and rapidly felts, until it becomes impenetrable. At the same time the temperature must not be allowed to rise above 100° C., or the filter tubes rapidly deteriorate and may be destroyed by fire.

Exhaust vapour filter bags must not be subjected to the action of dry heat from time to time such as, for example, arises during the heating up of the drier or possible emptying of the same. Dry, hot gases must therefore be conveyed away immediately. At the Jacob pit of the Gewerkschaft Wilhelmina at Frechen,[1] a tube connecting the tube drier with the exhauster is provided for this purpose, so that the vapours can be turned directly into the flue whenever they become too hot or too cold.

The starting and stopping of the Beth filter is effected automatically by means of a maximum-minimum thermometer which cuts out a motor above 100° C. and below 65° C., but keeps it running between these temperatures.

At many works it is considered that the varying temperature and moisture content of the atmosphere affects the efficiency of the filter pipes, but this point has not yet been definitely decided.

There is already a number of exhaust dust extractors working very satisfactorily with Beth filters which separate almost the whole of the dust in the dry state ready for pressing. Some modern installations are illustrated in figs. 213 to 216 and briefly described below.

Beth Filter and Dust-collecting Plant for Table Driers (fig. 213).—Each of these ovens, with thirty-two tables, has above it four filter cylinders each containing eight tubes. As may be seen in the diagram, the explosion tube can be arranged common to two neighbouring ovens. From the upper tables the vapours can be led direct into the open.

Experiments showed that from each oven of 525 sq. metres direct heating surface, 240 kg. of compressible filtered dust (0.45 kg. per sq. metre of heating surface) are obtained in 24 hours, in addition to the coarse dust sliding from the lowest table into the chamber attached to the oven.

[1] Baldus in *Z. Glückauf*, Essen, 1908, No. 0, p. 1765.

Beth Filter and Dust-accumulating Plant for Tube Driers (fig 214).—Each pair of tube driers has six filter cylinders, each containing eight tubes. Probably it is very much better to connect each drier to a

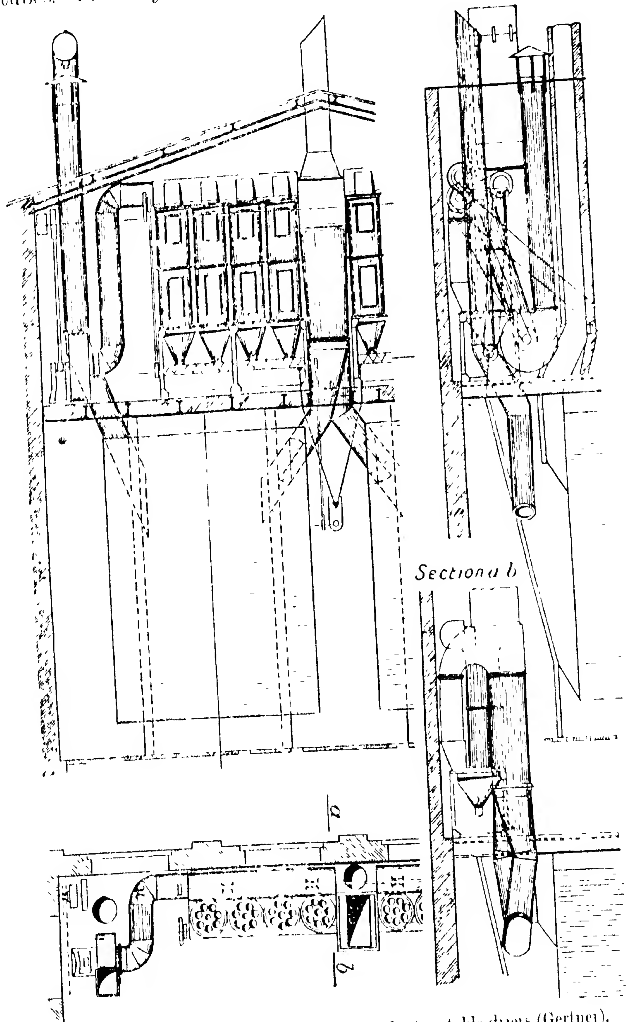


FIG. 213.– Beth filter and dust collector for two table driers (Gertner).

special filter plant in order to make it completely independent of neighbouring driers. This is of special advantage in case of repairs to the filter plant Dust is removed by means of a common worm conveyor.

Experiments on a tube drier of 668 sq metres of heating surface have given 1800 kg compressible dust (containing 15 per cent water), or 2·7 kg

per sq. metre of heating surface per 24 hours. This is six times the amount obtained in a table drier.

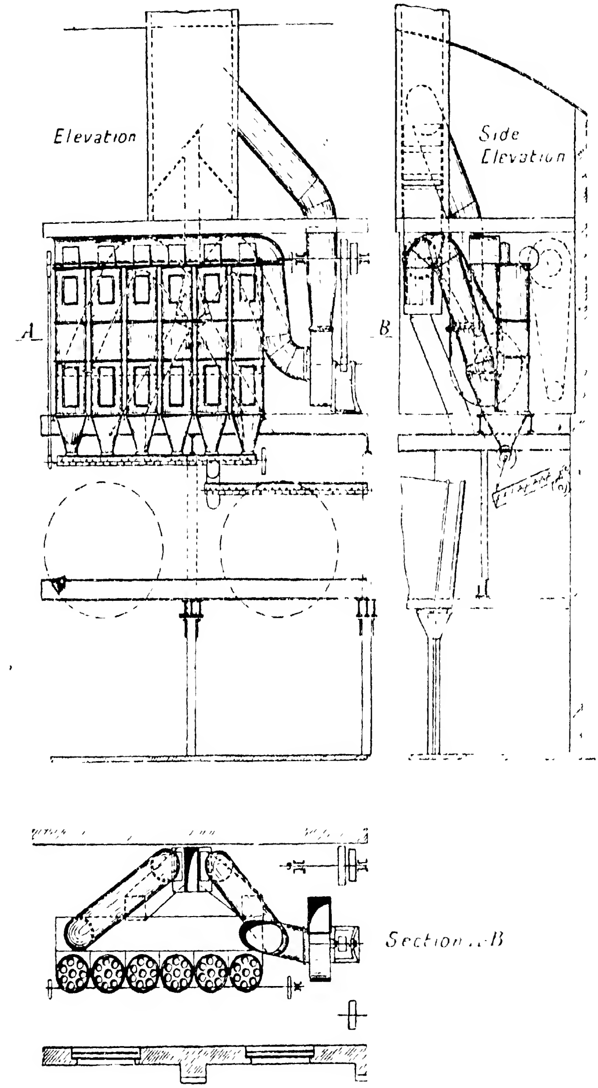


FIG. 214.—Beth filter and dust-collecting plant for two tube driers. Scale = 1 : 50 (Gertner.)

Beth Filter Plant for Tube Driers with Downcomers and Explosion Apparatus (fig. 215). This plant, designed for the Gewerkschaft

Wilhelmina at Frechen, consists of nine filters b and an exhauster c for each pair of tube driers. Between each drier and the filters a Beth explosion apparatus is arranged. Its arrangement and mode of

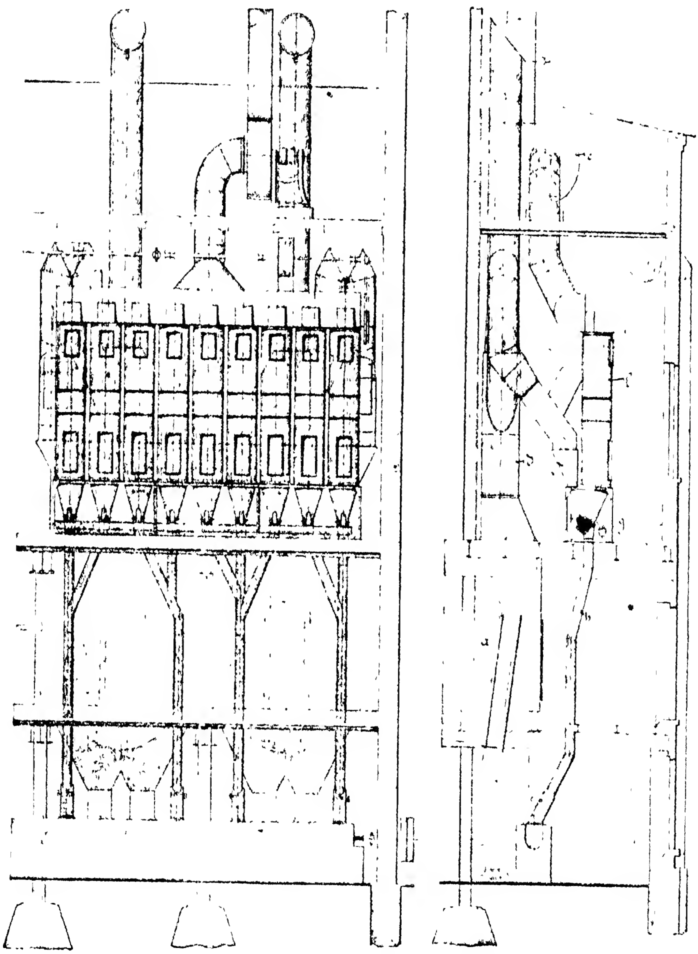


FIG. 215.—Beth filter plant for tube driers with falling tubes and explosion apparatus.

action is obvious from fig. 216 and the accompanying description. The vapours are led to the individual filters b through the channel e, the dust sinks into the collecting hopper, and finally falls into the oven spiral running along the ovens through the downcomer h, which are

much safer against explosions than worm conveyors The small spiral conveyor *g* in front of the filter collecting hoppers collects the condensed water and any possible slimes.

Beth Explosion Apparatus (fig. 216).—The valve *a* is arranged in such a way that the exhausted dusty air can pass through it readily The weight *b* combined with the valve axle by means of a lever keeps

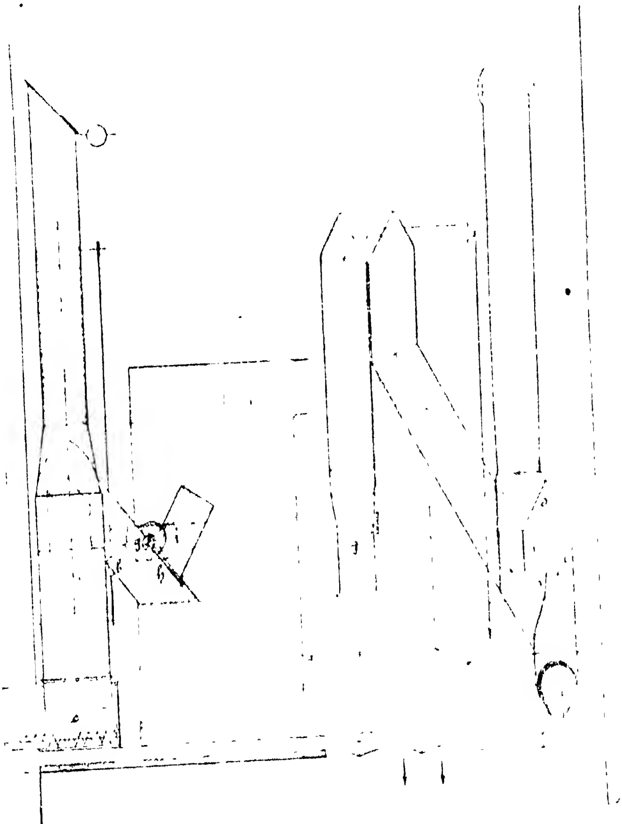


FIG. 216.—Beth explosion apparatus

the valve balanced in every position. When an explosion occurs in the collecting channel *c* the valve *a* is pressed against the solid wall so that with the aid of the weight *b* the passage to the filter is closed The outburst also presses back the valve *d* and finds its way into the open through the explosion tube *e*.

As soon as the damper *a* or *d* makes a slight movement the lever fastened to the damper shaft moves downwards in the direction of the

arrow tightens the wire rope f, and sets free the pawl g. As a result the damper h falls, closing the tube at the bottom and cutting off the main pipe from the filter. At the same time the damper is covered with a mixture of briquette ash and sand from the short pipe i, and this effectively prevents the passage of sparks.

7. *Dust Extraction by Means of Steam Jets.*

Such a method is applied at the Heye mine, Annahutte, Lower Lausitz, to the exhaust gases which have already been freed of most of the dust by the Boreas method. The finest dust is almost wholly settled out by blowing into sheet-iron pipes by means of Korting steam injectors. The product is too wet for pressing, so it is passed on to the boiler furnaces. This very effective method does not commend itself, on account of very high steam consumption and other deficiencies.

8. *Costs of Dust Extraction from the Exhaust Gases.*

In a correct representation of the working costs of an exhaust dust extraction plant it is necessary to take into account the value of the dust and slimes not used in the production of briquettes, and any possible diminution in the output of the drier, in addition to the amounts assigned to interest, liquidation, and the running costs for attendance, etc. The quantities of dust and slimes are to be credited with the value of a corresponding quantity of briquettes deducting the earlier costs of production and the expense entailed in bringing the material into the state in which it can be compressed.

On these principles, Gertner[1] has worked out the detailed costs of various Rhenish dust-extraction plants and has dealt with them in his Monograph. It is only possible, however, to deal with the following figures in this work:—

Installation of Eighteen Tube Driers with Counter Currents.—Total heating surface of the driers 5864 sq. metres. Total output per 24 hours - 333 tons of dry coal for briquettes.

Working costs of the dust extraction (fig. 209, I., II., III.a, and III.b) per double waggon = 10 tons of briquettes (excluding the increase of driving power and steam):—

[1] Monograph, p. 72.

(*a*) Installation costs	0·06 M
(*b*) Running "	0·15 "
(*c*) To equalise the 15 per cent decrease of output as compared with currents in the same direction (caused by equivalent increase in the total heating surface)	0·86
(*d*) Loss of material	0·04
Total	1·11 M

Installation of Twelve Tube Driers with Currents in the same Direction.—Total heating surface 8016 sq metres Total output in 24 hours = 580 tons dry coal

Buckau combined dust extraction similar to that illustrated in fig 205 with partial inclusion of the internal dust extraction The mud is filtered and the slimes burned on a Frankel trough grate (p 488)

Working costs per double waggon of briquettes :—

(*a*) Plant, excluding the appliance for filtering slimes	0·316 M
(*b*) Working costs	0·183 "
(*c*) Filtration of slimes	1·044
(*d*) Material lost, 11,700 tons slimes	1·120 "
Total	2·663 M
Deduct the counter value of the slimes as fuel	0·833 "
Leaving	1·830 M

Installation of Twelve Tube Driers with Currents in same Direction Total heating surface = 5472 sq. metres. Total output in 24 hours = 368 tons of dry coal

Working costs of dust extraction by the Boreas method as modified by Emonds (p 494) per double waggon

(*a*) Plant	0·518 M
(*b*) Running costs (incl. 86,406 c m. water at 2 pf.)	1·209 "
(*c*) Material lost, 10,800	1·636 "
Total	3·363 M.

The main facts to be observed from a comparison of these three methods of dust extraction are as follows :—

Dust extraction with counter currents is considerably dearer even

in plant costs than extraction by means of like currents, since an amount must be reckoned for equalisation of the decrease in output (*c*). The running costs and the losses of material are, however, comparatively small, while in the like current installation the reverse is the case. The methods in which no use is made of the slimes are the most costly.

Concluding Remarks on Exhaust Dust Extraction.—A dust-extraction plant which is good in every respect must be safe in working and sufficiently effective, but at the same time it must be as economical as possible. Economical requirements are complete utilisation of the capacity for output of the drier, prevention of unnecessary withdrawal of dust from the dry coal, every possible hindrance to loss of material in the shape of quantities of dust or slimes which cannot be turned to account—above all, moderate cost of installation and the lowest possible running costs in wages, materials, power, etc

The requirements of working, safety, and efficacy are fulfilled by the simple wet and the numerous combined dry and wet methods of exhaust dust extraction to a greater or lesser degree, usually however at the cost of economy. The simple wet method is the least economical, partially because of the low value of the bulky dust slimes produced and partially on account of the very large amount of water used in sprinkling. On the other hand, a purely dry method, which is cheap and works without loss of material, is the most advantageous from the point of view of economy, and undoubtedly deserves preference, if it is not considerably behind the other methods in point of view of safety and efficacy.

Newer designs and systems of dry separators provide sufficient safety in operation and are satisfactory as regards the sorting out of coarse and medium fine dust, but they usually fail to deal with the finest dust. It is often necessary therefore to provide a supplementary wet method (by means of spray nozzles) in order to precipitate the fine dust, such as is considered indispensable for the completion of the dust extraction, in ordering so many new installations. As a result, the costs and disadvantages of the sprinkling, the conveyance and value or further handling of the dust slimes, etc., must be taken into account.

In more recent times, however, success has apparently been attained at many works by means of one or another of the systems already described (Scheibe, Michaelis, Beth, etc) in extracting the dust from the exhaust exclusively in the dry way and recovering all the dust, or at least the major portion of it, in a condition suitable for pressing. It is,

however, yet to be ascertained how high the costs of the practice on a technical scale will prove to be over a long period of time, and whether and how far the method will commend itself, particularly when using different classes of coal. If the economical results and the further experiments turn out satisfactory, possibly after alterations, considerable progress will have been made, and the widely applied combined dry and wet methods of dust extraction will be more and more replaced by simple dry dust extraction

IV. Internal Dust Extraction.

Internal dust extraction has for its object the removal of dust from the rooms of the factory, above all, therefore, the exit of dust from the various working arrangements must be prevented. To this end, the sources of dust must be covered and rendered dust tight as far as is possible, but this is not sufficient, since certain leakages in working are unavoidable and, in addition, the vapours arising from the hot coal cannot be removed by any means, and this is necessary for the prevention of the formation of dangerous condensation products Exhaustion of the dust therefore becomes necessary but the atmosphere can no more be led into the open than the exhaust dust The dust must be collected and turned to account in as efficient a manner as possible Suction must proceed with so small a diminution of pressure that the entrance of dust into the rooms of the factory is effectively prevented, and that only the very finest particles of dust and water vapour are carried away in the stream of air

Here and there the natural draught of the drier flue, in addition to the appliances of the exhaust dust extraction are used to produce suction, but with inferior results however

For the artificial suction there are utilised —

1. Steam jet exhausters which cause the precipitation of dust by moistening in so far as it has not already separated out in the spaces of enlarged cross section provided in the conveying pipes

2. Fans, which either —

(*a*) Blow the dusty air into the boiler fires (Haase patent),

(*b*) Lead it to a cloth filter plant (Beth system),

(*c*) Discharge it into the exhaust dust-extraction appliances, or

(*d*) Subject the dust to the action of centrifugal force in order to obtain dust valuable for pressing, or subject it to a combined method of dust extraction

As a rule, the dust is concentrated towards one of the aforementioned places from the individual working appliances, by means of a sufficiently wide collecting channel into which the exhaust pipe opens out.

The suction can be regulated in each pipe by means of a throttle valve, made accessible by means of slides or doors. A worm conveyor is usually employed to remove the compressible dust which soon collects in the collecting channel.

In the Halle district a special dust extraction is enacted for the dust arising during pressing (see p. 182 above), a feature which is not demanded in the Bonn area.

1. *Internal Dust Extraction by Steam Exhausters.*—The dust extraction is set in operation, regulated, and cut off by means of a steam valve. Steam exhausters, particularly those of the Gebr. Korting Akt.-Ges. of Kortingsdorf, near Hannover, have been largely applied for a long time. They are simple in construction, easily regulated, take up little space and are cheap to instal. They are able to remove satisfactorily the dust from the factory rooms, but require a large amount of steam to precipitate completely the dust in the moist or wet state. Further disadvantages are that the precipitate is usually lost on the waste heap, that the exhauster chambers must be cleansed regularly from the dust and water mixture, and that during its removal it is scarcely possible to prevent the scattering of dust.

In the usual arrangement the Korting exhauster stands in the fourth division of a chamber situated outside the factory. The chamber is provided with three vertical division walls open at the bottom and top, alternately causing the dusty air entering the first section to fall and rise and ensuring its coming into contact with the water covering the floor. The water collects from a pipe conveying a steady stream of waste water from the pressing operation (press cooling water, slime water from the press channel when the wet method of removing stamp waste is employed), and overflows from a pipe in the fourth division, so that a definite head of water (usually 100 mm.) is always kept in the chamber.

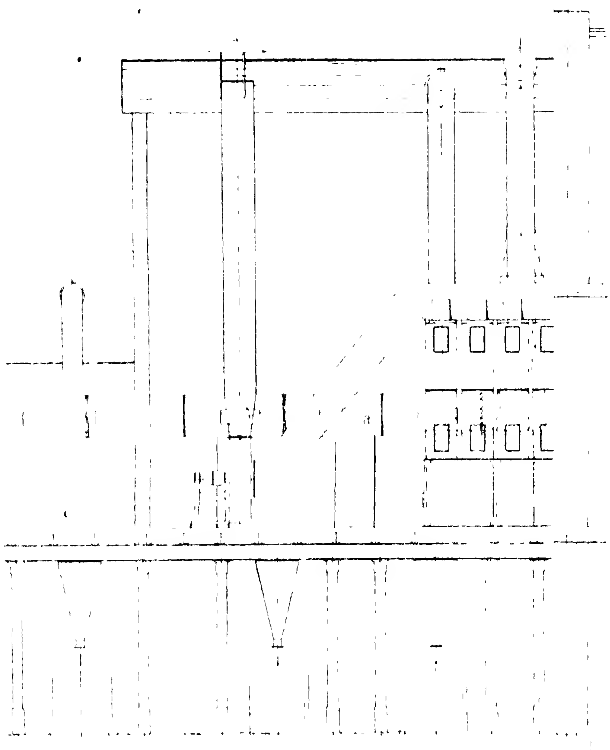
2. *Internal Dust Extraction by means of Fans.*

(*a*) See p. 486, fig. 198, for the Haase method of burning the dust.

(*b*) The dry method of dust extraction by means of suction tubular filters is largely carried out by the Beth system, especially in the Rhenish district, where it is replacing the previously employed steam exhauster system to an increasing extent. It is also finding increasing application in other districts such as Lower Lausitz, Brunswick, and

ntly safe in working.

[1] Monograph, p. 87, fig. 39.



... it is also finding increasing application in other districts such as Lower Lausitz, Brunswick, and

others. One of the most modern plants of this description is briefly described below, with reference to the account of this method given under the exhaust dust extraction (p. 506 *et seq.*, figs. 210 to 216).

Internal Dust Extraction from the Storeroom and Press House by means of a Beth Filter with Explosion Apparatus.—This plant was subsequently added in 1908 by the firm of W. F. L. Beth to a previously existing storeroom and press house at the Trene pit at Offleben (Braunschweigischen Kohlenbergwerke).

The individual sources of dust (dry elevators, storerooms, worm conveyors, feeding rolls ("coffee mills") of the presses and press channels in front of the stamps) are connected to one of the two collecting channels *a* by means of pipes, which rise or fall abruptly in order to prevent accumulations of dust. From the channels *a* the dusty air is sucked off by one of the Beth exhausters arranged right and left, and arrives at an explosion apparatus *c* in the back structure of the filter *b*, to have the dust removed in the filter pipes, and issue through an inclined tube to the fan which blows it into the open through a horizontal pipe.

The construction and mode of action of the explosion apparatus are described on p. 513 and shown in fig. 216. The dry dust shaken from the filters is conveyed by the collecting worm to a rising worm conveyor (fig. 217), which conveys it to a distributing worm situated below the storeroom in order that it may be thoroughly mixed with dry coal to prepare for compression.

The whole of the plant is readily seen, easily accessible, and is provided with numerous safety arrangements, but has not been in action long enough in order to give results which are free from criticism. With regard to suitable filter material for the local hard coals which are difficult to crush and are consequently very dusty, further experiments are in progress.

Similar suction filter plants for internal dust extraction have been recently built by Simon Buhler & Baumann Muhlenbauanstalt und Maschinenfabrik of Frankfort a. M.

Experiments which have been carried out at a Rhenish briquette factory on the use of a pressure filter plant led to no successful results (according to Gertner[1]). It is very difficult to find a filter material which will effectively retain dust when dusty air is blown through it. Further, the pressure filter dust collector does not appear to be sufficiently safe in working.

[1] Monograph, p. 87, fig. 39.

(c) Introduction of the dusty air, drawn off by means of a fan, into the exhaust dust-extraction process is not suitable, since only an incomplete separation of dust can be attained in this way.

(d) Dust extraction with the aid of centrifugal force. The Boreas method (compare p. 494 and fig. 203) by itself appears to be insufficient for the fine dust particles of the internal dusty air, and should always

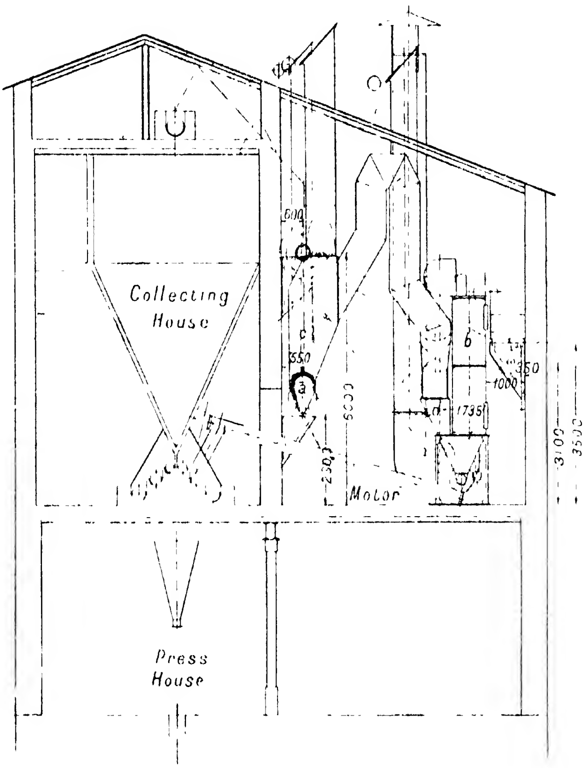


FIG. 217.—Internal dust extraction by means of a Beth filter with explosion apparatus (See Plate V.)

be supplemented by a subsequent sprinkling or moistening by means of a jet of steam.

The centrifugal separator of R. Scheibe & Sohne, Leipzig (p. 495, fig. 204), had not been applied for internal dust extraction up to the year 1909.

A few examples of the new centrifugal dust extractor of C. Michaelis, Cologne (p. 496), will shortly be installed for this purpose. [1909.]

The centrifugal dust-destroying jets by O. Sichtig & Co., Karlsruhe (p. 496), have, for a short time, been used here and there for internal

dust extraction after the preliminary use of a dry separator. According to Gertner,[1] the result was not quite satisfactory.

Retention of the Dust coming out of the Press Mould in front of the Briquette Rope.—For this object a sheet-iron box which can be taken to pieces is arranged in front of and below the press body, at the Friedrich Wilhelm I. pit, Costebrau, Lower Lausitz.[2] As far as is necessary the box is keyed up and covered with insulation material, and is connected by means of a narrow pipe to a channel in which the cooling water from the mould flows This extracts the dust, consisting mostly of fine briquette waste. This simple arrangement, perfect in action, renders superfluous the generally adopted, unreliable method of attempting to retain the dust issuing in front by means of intermediate plugs of damp cleaning waste or cloths

Concluding Remarks on Internal Dust Extraction—The required freedom from dust of the atmosphere of the rooms of the factory can be attained with ease in a perfectly safe manner by the means described above. As in the case of dust extraction from the exhaust vapour, the important problem is to recover the dust in such a way that it can be utilised as far as possible. In this respect the suction filter methods and those centrifugal systems in which the dust is separated dry, stand first, since they render possible the favourable application of the dust to the manufacture of briquettes. On the other hand, the still widely used internal extraction by means of steam jet exhausters, with the help of water and separating chambers, deliver the dust in the moist or wet condition, in which it is usually of no value

Clarifying the Slime Liquors Removal of Slimes, Slime Filter Plants.—The slimes which are often obtained in large quantities in wet extractions, especially from the exhausts, cannot be turned directly into the streams or rivers. With perfect justice the controlling authorities only permit the outflow of clear waste water Many works simply allow the slimes to flow into exhausted open workings, and allow the water to trickle away, or pump it off after natural filtration, while the mud remains behind and is lost. At other places, spacious ponds or clearing tanks have been provided from which the mud has to be removed from time to time, necessitating the provision of reserve tanks.

The deposition of mud in such tanks is promoted by repeatedly reversing the stream of slimes by dividing walls and by providing filter beds of sand, etc., which must, however, be frequently cleaned or completely renewed.

[1] Monograph, p. 89

[2] Richter, *Die deutsche Braunkohlenindustrie*, 1907, ii p 50

Removal and transport of the mud necessitates much unproductive work and cost, amounting to 6 to 8 pf. per ton of briquettes in two cases given by Gertner.[1] If the mud is thrown on to a heap and left uncovered, it is dried by the wind and becomes a source of danger because of risks of fire in the summer months.

Recently, the Maschinenfabrik Buckau, the Zeitzer Eisengieszerei und Maschinenbau Akt.-Ges., and others have constructed special slime filters and introduced them at several works with good results. In these appliances clear water is removed from the slimes in chests provided with filter cloths and with the aid of steam or compressed air the mud is concentrated to 55–60 per cent. water and carried to the fuel in the boiler house by means of a band conveyor. Such a slime-filtering plant is dealt with in Section X. under the description of the Dora and Helene briquette factory.

According to a cost sheet given by Gertner,[2] the installation costs of a Buckau slime filter amounted to 28,000 M., the total working costs 10.5 pf., and the value of the slimes recovered 8.4 pf.; consequently, the pure costs of filtering amounted to 2.1 pf. per ton of briquettes.

[1] Monograph, p. 23.

[2] *Ibid.*, p. 27, where a new filter plant with hydraulic seal and mechanical discharge, constructed by the Zeitzer Eisengieszerei, is also described.

SECTION VIII.

PROGRESS, COOLING, LOADING, AND STACKING OF THE BRIQUETTES. REPAIR WORK.

A. PROGRESS AND COOLING.

THE blocks produced by the various presses of a brown-coal briquette factory issue as complete ropes which are pushed backwards and forwards in so-called briquette launders (running and cooling launders, fig. 218) to the railway waggons, into which they are loaded directly or, when there is a deficiency in the sales, they are pushed to the storage

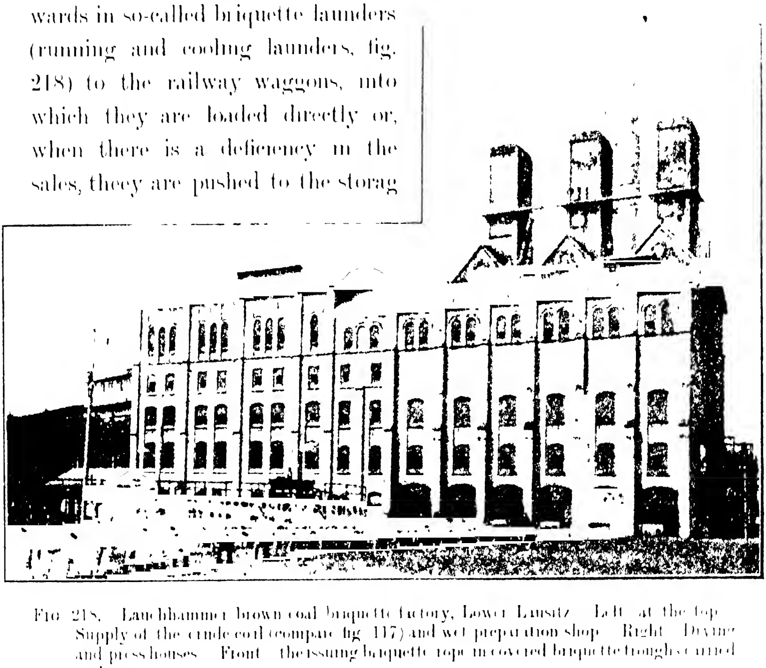


FIG. 218. Lauchhammer brown coal briquette factory, Lower Lausitz. Left at the top: Supply of the crude coal (compare fig. 117) and wet preparation shop. Right: Drying and press houses. Front: the issuing briquette rope in covered briquette troughs carried on beams.

bins or open storage places, where they are stacked for loading at a later date. On the way to their destinations the briquettes should cool as much as possible. In the absence of special cooling media such as cold water, etc., this is allowed to take place by means of a free access of air

but this requires long troughs and correspondingly extensive grounds, or special batteries of gutters when such grounds are not at hand (see below).

The briquette troughs are riveted up of flat and angle iron in such a way that the briquette rope to be taken up is led away with safety, but with as little as possible frictional resistance and copious access of air. Fig. 219 shows a section of a briquette trough of modern construction which has commended itself in practice. By means of the upper bent cross-stays holding the long rails below, arching up and ejection of portions of the briquette rope is effectively prevented. The

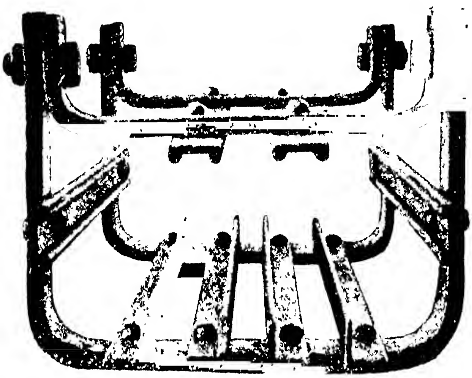


FIG. 219.—Section of a briquette trough.

external width of the trough amounts to about 250 mm for the ordinary 7-inch stones.

Loading troughs built in a more or less different manner for domestic and industrial briquettes (occasionally provided with knives) are illustrated in figs 174, 191, and 192

Briquette troughs are built up in sections of 1 to 1.5 metres in length, laid one after the other on wooden beams (pile driven) at distances of about 2 metres Junctions are made strong with broad, flat-iron bars and cotter fastenings. The first section of the trough is hooked on to the press body at both sides.

The path of the briquette troughs and ropes need not always be straight and horizontal; they can take the form of smooth, slight curves and rise or fall to a moderate extent in case this becomes necessary as a result of the position of the loading track or storage place relative to the press front.

The length of the trough usually amounts to between 60 and 150 metres, the resistance to be overcome by the press increasing with the

length, which is also determined by the important factor—length of time required for the cooling of the briquettes This in turn depends upon the thickness and number of blocks produced in unit time

In launders of 100 to 150 metres in length, the time for cooling of 7-inch domestic briquettes of normal thickness using a 80-, 90-, or 120-stroke press lasts between 24 and 54 minutes, as will be seen from the following table. With a 130- to 140-stroke press, the time is correspondingly shorter.

The cooling attained in a launder of even 100 metres length is often scarcely sufficient, as witness the following example —

At a Lower Lausitz works using soft coal, the briquettes issue from the press at 56°, from the briquette trough 100 metres long at 38°, and in the next six hours in the railway waggon they heat up to 52°, after which they cool down comparatively quickly. Briquettes charged directly into the waggons from the press heat up to such an extent that they take fire

Number of Briquettes produced per min		80	90	100	110	120
Length of briquette ropes per min (m)		2·8	3·15	3·5	3·85	4·2
Length of time in cooling in briquette trough, mins	100 metres	35·7	31·7	28·6	26	24
	150 ,,	53·5	47·5	42·9	39	36

Works using hard coals which heat up considerably during compression require correspondingly longer troughs

To ward off the sun's radiation and as protection against atmospheric dust, it is recommended that the briquette trough be covered with a protecting roof built up of boards nailed together and resting on the beams so that it can be easily removed (fig 218)

Batteries of Cooling Troughs—It has been found by long experience that a cooling time of several hours acts in the interest of loading and transport, and as a result a number of works, especially in the Rhenish district, particularly where there is not enough space for the installation of long troughs, have been provided with a cooling battery for each press. The battery is installed between the front and back ends of the main trough in such a way that the joining ends are movable [1]

Each battery contains about three series each of four cooling troughs situated one above another, and of such a length that they are filled in from 15 to 20 mins When the cooling gutter is filled from the main gutter the second cooling trough is brought into position, and the battery is only joined to the main gutter when it is completely full. Then the briquettes are pushed forward by the oncoming fresh rope on to the f[illegible] portion of the main launder,

[1] *Die deutsche Braunkohlenindustrie*, ii p. 15

and this is done in turn with the whole of the battery, which at the same time becomes recharged with fresh stones

In this way the briquettes arrive at the loading station after a cooling period of at least three hours

The continual attention of two men is required to change the briquette rope.

Simultaneously with the cooling, a certain degree of expansion and removal of the vapour from the briquettes occurs, especially after the removal of the external pressure.

This phenomenon can probably be traced to the fact that the air mechanically entangled with the small coal is not removed during compression but becomes compressed After removal of the pressure it forces the particles of coal apart until equilibrium is regained. The expansion amounts to about $\frac{1}{20}$ of the length.

Therefore the briquettes must not be packed quite tightly either in loading or storing

B. LOADING BRIQUETTES

Loading domestic briquettes is generally effected by hand, in the following manner The loader, standing in the railway waggon, lifts from the steadily advancing briquette rope the front $\frac{3}{4}$ to 1 metre length of briquettes with both hands, which are suitably protected by thick leather gloves In this way the individual briquettes are pressed close together and the whole length of rope is placed in the waggon in a definite order (organised loading).

Along one of the front sides in the first transverse series the briquettes are laid on top of one another in horizontal layers so as to stand on their narrow long sides, in the second series they are built up in adjacent vertical columns so as to lie on their broad sides, the third series is arranged like the first, the fourth like the second, and so on The main object of this lies in the formation of vertical air channels which by this arrangement are built up naturally as a result of the peculiar shape of domestic briquettes, and admirably serve the purpose of promoting the cooling of and removal of vapour from the briquettes. At the same time, the expansive tendency must be taken into account by not packing the individual layers close to each other and to the walls of the waggon. The sides might otherwise be burst open during violent shunting.

Loading of small lump industrial briquettes is not effected by hand, but by simply all... g the stones to fall into the waggon from the

briquette launder. The numerous hollow spaces produced render special air channels superfluous.

In the Rhenish district the attempts to introduce this "chute" method of loading for domestic briquettes are becoming more and more pronounced, although the briquettes suffer from fracture and crumbling (see Section XII.)

Weight of Material.—A double load (double waggon) of freshly compressed briquettes generally loses 3 to 4 cwts., and sometimes more, by evaporation during railway transport. In order to equalise this, a corresponding excess weight of briquettes, usually amounting to 1.5 or 2 per cent., is loaded up so that a double load of fresh briquettes does not amount to 10,000 kg. but to 10,150 or even 10,200 kg., in order that it will represent not less than 10,000 kgs. of briquettes at its destination. The number of domestic briquettes of 6 inch, 7 inch, and 8 inch lengths which go to make up a double load are given on p. 288.

Weighing the loaded waggons is carried out in very much the same way as described for coal briquettes on p. 188. Loading for rail transport is generally effected in roomy loading sheds covering the loading track, open at both ends and provided with landing places at both sides. The length of the sheds depends upon the length and number of the waggons to be loaded simultaneously. A double loader is 8 metres long. The number of waggons depends upon the number of briquette presses in operation at once. Accordingly a shed of about 50 metres in length is required for a six press factory.

The loading staff consists as far as possible of young or female workers under the superintendence of an overseer and weighing manager.

C. STORAGE OF BRIQUETTES.

During deficiencies in the demand which occur every year, often at the same period, and in order to prepare for the heavy demands which occasionally crop up as a result of abnormal weather or other conditions and may persist for a considerable time, it is essential that a stock of briquettes should be kept at every works. This may be effected in the loading sheds if they are arranged for the accumulation of stores or in special storage sheds, or even in the open in the factory yard.

Storage in covered sheds which best protect the briquettes from the sun's radiation, atmospheric dust, and against the influence of temperature and moisture changes of the atmosphere, is to be decidedly preferred to storage in the open. In exposed storage the above in-

fluences make themselves felt detrimentally in two ways: they favour the cracking and crumbling of the briquettes, and the formation of small coal and dust, thus favouring spontaneous ignition.

Finely divided coals which absorb the oxygen of the air very readily and oxidise with the development of heat, warm up more and more rapidly after thorough moistening, so that if the heat is not continually led away, spontaneous

FIG. 220.—Column of domestic briquettes at the Dusseldorf Exhibition.

ignition takes place. This danger naturally becomes greater the hotter the briquettes are taken away to stacking and the higher they are stacked, since this largely prevents the loss of vapour from, and the cooling of, the lower layers.

As a result of spontaneous ignition, large stores of briquettes have been destroyed by fire in the factory yards. An effective method of protection against spontaneous ignition consists in piling the briquettes not more than 15 layers high in the cooler seasons and not more than 5 to 10 in summer, allowing them to cool for a week (continuing the

stacking in another place), then strewing a layer of fine coal (5 to 10 mm. in thickness) over them and only then laying down a new layer.

In the interest of the protection of the stores, and especially to promote convenient loading, it is most advantageous to be able to stack those briquettes which are not immediately saleable in the loading sheds. The loading platforms can readily be adapted to taking certain quantities of briquettes if they are made sufficiently wide and safely supported below. In order to house further stores, the loading shops can be provided on the press-house side with several outbuildings through which the briquette troughs can be taken.

If, however, a briquette factory is compelled, by virtue of its geographical situation and particular market conditions, to store up its whole production not only for a day but for a week or even longer, special storage sheds of ample capacity or at least covered storage places can scarcely be dispensed with. It is recommended that such stores be arranged in such a way that their filling and subsequent emptying for loading can be accomplished without unnecessary intermediate transport and with the expenditure of as little wages and power as possible. If the stores are completely enclosed on all sides, which is not usually necessary, care must be taken to provide good ventilation, which can be obtained by means of perforated walls. Sufficient interspaces should be left in stacking. Fig. 220 shows a column of "Union" domestic briquettes shown at the Dusseldorf Exhibition by the Briquette Selling Agency of Cologne.

D. REPAIR WORK.

Every brown-coal briquette factory requires an efficient grinding shop, repair shop, and forge equipped according to its size, in order that portions of the working appliances which wear out more or less rapidly, especially the press moulds and stamps (see p. 449 *et seq.*), the shovels, the stirring arms of steam table driers (see p. 384), etc., and broken or otherwise damaged parts can be repaired. In addition, missing parts and easily made replaceable parts should be capable of being produced. The more difficult repairs, such as replacements of cast iron, cast steel, case-hardened parts, etc., are most conveniently ordered from the firm who supplied the machine. It is recommended that such parts as may want replacing at short notice should be kept in stock.

If the briquette factory is situated near the mine, its workshop

can generally deal with the requirements of the mine, in which case it must be accordingly adapted in size and equipment.

The workshop must be situated either in the factory building or in an outhouse. At large works with considerable mining requirements it is best placed in a special low building, which must be provided with a room for the staff in addition to a stores

The equipment of a repair shop and forge should include lathes, drilling, and planing machines, a rapidly rotating grinding wheel, vices, forge fire with blast, anvils, etc.

The individual machines should be belt-driven from the engine of the factory, or by small electric motor, the latter being adopted at most modern factories

SECTION IX.

POWER ECONOMY.

General.—Power economy, *i.e.* the most economical production distribution, and use of the motive power, plays an important rôle in the extensive industry of brown-coal briquetting, particularly at such works as provide considerable power for removal, transport, supply of water, etc., in extensive open or deep workings. This is specially the case where one and the same undertaking possesses several large pits and factory plants at considerable distances apart. In all these cases, production of steam and electrical energy in one or several separate or connected central stations, according to the particular circumstances, can produce great advantages and economies.

A. STEAM ECONOMY.

I. STEAM USED IN BROWN-COAL BRIQUETTE FACTORIES.

The amount of steam used in a briquette factory depends primarily on the amount of water to be removed from the crude brown coal. On pp. 347 to 349 is given the method of calculating this quantity in detail. In addition, the amount of water to be removed per kilogram and per double load (double waggon = 10,500 kg.),[1] assuming a residual moisture content of 15 per cent., is calculated for water content of the crude coal varying from 40 to 60 per cent.

In the following example, abridged from an admirable treatise by F. W. Foos,[2] only those figures are taken into account which have been determined for a 40, 50, and 60 per cent. of moisture in the crude coal, assuming 15 per cent. residual water.

[1] Taking into account material weight and an excess for loss in dry coal as a result of dust and refuse (about 500 kg.).

[2] "Der Dampfverbrauch in Brikettfabriken," F. W. Foos, Halle a. S., *Z. Braunkohle*, v., 1907, No. 42, p. 667 *et seq.*

TABLE I

Water in the crude coal	40 per cent	50 per cent	60 per cent.
Water to be removed per double waggon of briquettes (approx.)	4400 kg	7350 kg	11,820 kg

These amounts of water require for their evaporation certain amounts of heat depending upon the relative moisture in the atmosphere (see above, p 351 *et seq.*), which varies considerably with the weather conditions

For Central Germany, assuming an average yearly temperature of +8 or 8.5° C., and a relative moisture content of the atmosphere of 75 per cent, the amount of heat required to evaporate 1 kg of water, including the radiation losses of the drier, can be taken as 850 cals. approximately.

From this the necessary drying steam for the prevailing steam pressure in the drier is determined from

$$W \frac{850}{\lambda - q} = D_{tr} \text{ kg drying steam,}$$

in which

λ indicates the total heat of a kg steam in cals

q „ „ fluid „ per kg steam „

W „ „ amount of water in kg. to be evaporated per double waggon of briquettes

At a steam pressure of 2 atms in the drier

$$D_{tr} = W \frac{850}{617 - 164} = 1.66\ W$$

TABLE II

Water content of the crude coal	40 per cent	50 per cent	60 per cent
Quantity of drying steam per double waggon	7300 kg	12,200 kg	19,620 kg

This quantity of drying steam, which depends first and foremost on the moisture in the dry coal, is essential under all circumstances, and must be provided in some way or another

Now, if we take the case of a briquette factory with a daily output of 24 double waggons, working with 10 atms. boiler pressure and 2 atms steam pressure in the drier, having in operation

4 briquette presses with throttle regulation, large model cylinder diameter of 500 mm and 700 strokes, each of 110 indicated H.P.,

2 steam engines with expansion valve gearing, 400 mm cylinder diameter 700 strokes, each of 100 indicated H.P.,

the steam used by each steam engine is made up of the sum of three parts:—

(1) Steam usefully employed s'
(2) Cooling losses s''
(3) Steam lagging losses s'''

Total steam used s_i per I.H.P.

The cooling losses arise during the inlet of steam and during the expansion of the steam on the power stroke. Therefore, the working steam per hour amounts to —

$$D_n = (s' + s'' + s''')\ N_i = N_i S_i,$$

while the steam used per hour for drying is

$$D_n = (s' + s''')N_i = (s_i - s'')\ N_i$$

(*a*) For the previously described briquette press with throttle

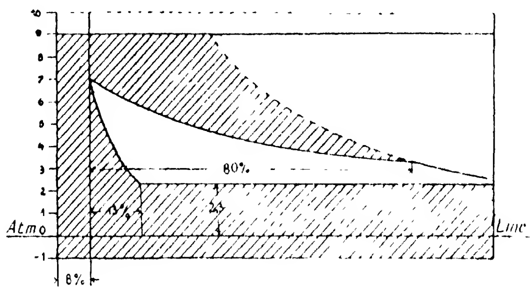


FIG. 221.—Indicator diagram of a briquette press with throttle valve. (According to Foos.)

regulation, the steam required according to the indicator diagram works out approximately to

$$s' = 27{\cdot}5 \text{ kg}$$
$$s'' = 3{\cdot}3 \text{ ,,}$$
$$s''' = 1{\cdot}2 \text{ ,,}$$

$s_i = 32{\cdot}0$ kg. power steam per I.H.P.

Further

$s' + s''' = 27{\cdot}5 + 1{\cdot}2 = 28{\cdot}7$ kg. drying steam per I.H.P. hour

Therefore, $\dfrac{28{\cdot}7}{32{\cdot}0} \times 100 = 90$ per cent. of the working steam is realised as drying steam, and scarcely 3·3 kg. steam per indicated horse-power hour is utilised in the real production of power.

The two steam engines with expansion valve gearing work some-

what according to the indicator diagram in fig. 222, from which the steam used works out

$$\begin{aligned} s' &= 13{\cdot}5 \text{ kg} \\ s'' &= 3{\cdot}5 \text{ ,,} \\ s''' &= 1{\cdot}0 \text{ ,,} \\ \hline s_i &= 18{\cdot}0 \text{ kg driving steam per I.H.P. hour,} \end{aligned}$$

and further:—

$$s' + s''' = 13{\cdot}5 + 1{\cdot}0 = 14{\cdot}5 \text{ kg drying steam per I.H.P. hour.}$$

Consequently, $\frac{14{\cdot}5}{18{\cdot}0} \times 100 = 80{\cdot}5$ per cent. of the working steam is recovered as drying steam, and the real power production of 3·5 kg steam per indicated horse power is required.

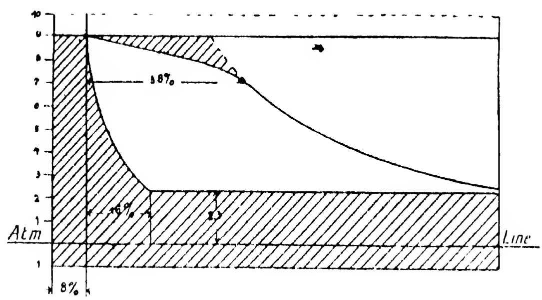


FIG. 222.—Indicator diagram of a steam engine with expansion valve gearing (According to Foos.)

Therefore, so long as the exhaust steam is carried to the drier, this method of working represents the most favourable production of power, since in this manner only about half the steam is used per indicated horse-power hour as is utilised in the best combined engine provided with condensers.

In the running of a briquette factory the following quantities of steam are required:—

TABLE III

	Driving Steam per hour.	Drying Steam per hour.	Ratio $D_t : D_a$.
Four briquette presses = 440 I.H.P.	14,100[1]	12,630	0·900
Two engines = 200 I.H.P.	3,600[2]	2,900	0·805
Total	17,700	15,530	0·880

[1] 14,100 = 440 × 32 kg., 12,630 = 440 × 28·7 kg.
[2] 3,600 = 200 × 18 kg., 2,900 = 200 × 14·5 kg.

Consequently, an average of 12 per cent. of the working power of the engine escapes as condensation or cooling losses.

The distribution of the steam used in a briquette factory is somewhat as follows :—

TABLE IV.

Water Content of the Crude Coal	Working Steam.	Drying Steam.			
		Existing.	Necessary.	Remaining.	Missing.
per cent	kg	kg	kg	kg	kg
40	17,700	15,530	7,300	8,230	
50	17,700	15,530	12,200	3,330	..
60	17,700	15,530	19,620	.	4,090

An excess of drying steam is produced for coals containing 40 and 50 per cent. moisture, and could be saved directly if the briquette presses require less steam per indicated horse-power hour.

With a 60 per cent water content, however, the amount of drying steam produced is not sufficient in fact, a further 4090 kg is required. This can be obtained from the high-pressure mains by passing through a reducing valve In this way the total working steam required per double waggon of briquettes is —

TABLE V

Water Content of Crude Coal	Total Steam required per D W.
per cent	kg.
40	17,700
50	17,700
60	21,790

(*b*) If, however, the briquette presses are also built with expansion valve gearing, the result is manifested in various economical advantages in the whole working. The steam used by such a briquette press is shown in the diagram given in fig. 223.

$$s' = 13\cdot5 \text{ kg.}$$
$$s'' = 3\cdot5 \;\;,,$$
$$s''' = 1\cdot2 \;\;,,$$

Total . $s_{\prime} = 18\cdot2$ kg. working steam per I.H.P

$s' + s'' = 13\cdot5 + 1\cdot2 = 14\cdot7$ kg. dry steam per I.H.P. hour.

Therefore, $\frac{14\cdot7}{18\cdot2} + 100 = 81$ per cent. of the working steam is recovered as drying steam.

In the working of the briquette factory the following figures are obtained for the steam used —

TABLE VI.

	Working Steam per hour.	Drying Steam per hour.	Ratio.
	kg.	kg.	
Four briquette presses = 440 I. H. P	8,000	6,500	0·810
Two engines = 200 I. H. P.	3,600	2,900	0·805
Total	11,600	9,400	0·815

The steam distribution in the briquette factory is —

TABLE VII.

Water Content of the Coal.	Working Steam	Drying Steam			
		Provided	Necessary	Excess	Deficiency
per cent	kg.	kg	kg	kg	kg.
40	11,600	9100	7,300	2100	
50	11,600	9100	12,200		2,800
60	11,600	9100	19,620		10,220

Compared with Table IV, the steam distribution has changed considerably. A slight excess of drying steam exists only in the case of

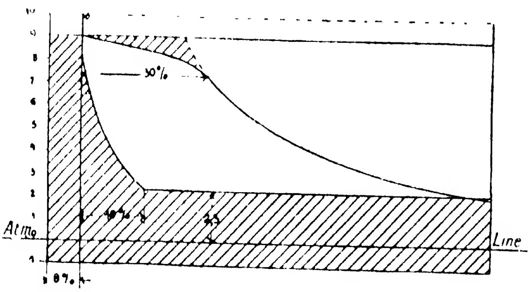


FIG. 223 - Indicator diagram of a briquette press with expansion valve gearing (Foos)

the 40 per cent. coal, and large additions are required in the cases of the coals with 50 and 60 per cent. water.

The total steam required per double waggon of briquettes is as follows —

TABLE VIII

Water Content of the Crude Coal	Total Steam used per Double Waggon of Briquettes.		Economy per Double Waggon Briquettes.
	Formerly.	Now	
per cent.	kg.	kg.	kg
40	17,700	11,600	+ 6100
50	17,700	14,400	+ 3300
60	21,790	21,820	30

Results.—With regard to the steam used per double waggon of briquettes, the improvements in the individual engines and briquette presses only provide advantages so long as the excess of drying steam is dealt with. Beyond this the improved engine cannot further decrease the total steam used per double waggon of briquettes, since this limit is determined by the process of drying itself, but there exists the possibility of an extraordinarily cheap production of power which without doubt, represents capital.

(*c*) Taking into account a briquette factory combined with a central electric station whose current is applied in the mine or in any other way, the engine of the station must be provided with condensers if the amount of drying steam required is covered by the briquette presses and driving engines of the briquette factory Apart from the use of superheated steam, and even with the most perfect construction, these machines would require about 6 kg of steam per indicated horse-power hour.

If, however, simple single cylinder engines exhausting into, and therefore working with the back pressure of, the drying apparatus are chosen for operating the central station, the amount of steam required works out as follows from the indicator diagram in fig 224 :—

$$\begin{aligned} s' &= 13{\cdot}5 \text{ kg.} \\ s'' &= 2{\cdot}25 \ \ ,, \\ s''' &= 0{\cdot}75 \ \ ,, \\ \hline s, &\ \ 16{\cdot}5 \text{ kg working steam per I.H.P.}, \end{aligned}$$

and further —

$$s' + s''' = 13{\cdot}5 + 0{\cdot}75 = 14{\cdot}25 \text{ kg. drying steam.}$$

Therefore, $\frac{14{\cdot}25}{16{\cdot}5} \times 100 = 86{\cdot}5$ per cent of the working steam is recovered as drying steam, and in reality only 2·25 kg. steam is required per indicated horse-power hour. This corresponds to a steam economy as compared with the complete condensing machine of

$$6 - 2{\cdot}25 = 3{\cdot}75 \text{ kg. per indicated H.P. hour}$$

To this relatively large economy must be added the advantages of simpler working plant as regards attendance and upkeep, and above all the cheaper cost of installation (single-cylinder engines cost only about half as much as compound condensing engines). All these points

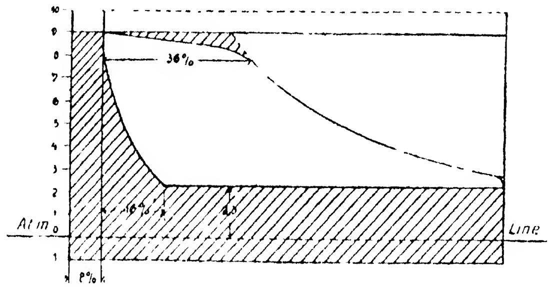


FIG. 221. Indicator diagram of a steam engine with valve gearing. (According to Foos.)

lead to a cost of production per kilowatt hour lower than can be attained by any other arrangement.

In the example cited (Table VII., columns 1 and 6), assuming 50 per cent. water in the crude coal,

$$\frac{2800}{14 \cdot 25} = 197 \text{ I.H.P.},$$

and with a coal containing 60 per cent. water

$$\frac{10,220}{14 \cdot 25} = 718 \text{ I.H.P.}$$

are obtained from 2·25 kg. steam per indicated horse-power hour.

Assuming that these horse-power hours must be obtained in some other way, then the steam economy in the case of the coal containing 50 per cent. moisture would be

$$197 \times 3 \cdot 75 = 740 \text{ kg.},$$

and for a coal with 60 per cent. water

$$718 \times 3 \cdot 75 = 2692 \text{ kg.}$$

These amounts must be added to the steam economies shown in Table VIII., which then becomes

TABLE IX.

Water Content of the Crude Coal.	Direct Economy in Steam.	Economy in Central Electric Station.	Total Economy in Steam.
per cent.	kg.	kg.	kg.
40	+ 6100	0	+ 6100
50	+ 3300	+ 740	+ 4040
60	30	+ 2692	+ 2662

In the year, calculated to a total output of 7200 double waggons = 24 double waggons per day, this represents—

TABLE X

Water Content	Steam Economy per Year	Coal saved per Year	Money saved per Year
per cent.	kg.	hl.	marks
40	44,000 000	315,000	31,500
50	29,100,000	208,000	20,800
60	19,167,000	136,900	13,690

In Table X. it is assumed that 1 hl of fuel coal weighs 70 kg., evaporates $70 \times 2 = 140$ kg water, and costs 10 pf.

Under certain conditions it is of advantage to work the briquette presses as economically as possible with regard to steam, *i.e.* fit them with expansion valve gearing. The widespread belief of the authorities mentioned below, that so long as the exhaust steam passes into the drier the steam used in the briquette press per indicated horse-power hour does not matter, is not always correct. The one and only determining factor is the economy of the whole plant.

F. W. Foos summarises the important points of the foregoing calculations in the following concluding sentences:—

"With regard to steam technicalities and economy in a briquette factory, the maximum point is reached when no exhaust steam is lost and simultaneously the maximum working power is produced from the quantity of steam required per double waggon of briquettes. A rule which is influenced by so many different factors as crop up in a briquette factory can only be expressed in this general form, and on this basis each individual plant must be carefully tested before any decisive alterations are undertaken."

The case of the Ilse Bergbau Akt.-Ges. (Ilse mine, Lower Lausitz) is a standard example in the sense of Foos' conclusions. According to Director Muller,[1] the rationally working steam engines and presses of the earlier undertakings (Ilse, Anna Mathilde, Renate, and Eva mines) have been placed in the position to give up about 700 H.P. on the opening of the new Marga field near Brieske (in the Senftenberg neighbourhood) without deleteriously influencing the efficiency of the previous undertaking.

The following small calculation from the report of Muller indicates

[1] *Z. Braunkohle*, 1907, No. 24, p. 401.

the way to be taken in order to improve the presses and power units of the briquette industry as regards economical working.

In the new Marga briquette factory[1] 50,000 double loads of briquettes are to be prepared annually from crude coal containing 59 to 61 per cent. moisture.

The drying steam required per double load of briquettes amounts to about 20,000 kg., consequently $\frac{50,000 \times 20,000}{300 \times 24}$ = about 140,000 kg. steam are required per hour.

The steam requirements of the 25 × 110 H P. presses with poppet valves necessary for the above requirements, assuming an initial pressure of 12 atms of steam superheated to 300° C and a steam pressure of 15 atms in the tube driers, amounts (according to the Ilse mine experiments) to

10·7 kg. per indicated horse-power hour

Consequently, 250 × 110 = 2750 I.H P. are required for the presses to produce the quantity of briquettes, or

$$2750 \times 10{\cdot}7 = 30,000 \text{ kg. steam.}$$

The steam requirements of the boiler feed pumps and the losses through leakages, etc., amount to about 20,000 kg. in a similar plant, so that

$$140,000 - (30,000 + 20,000) = 90,000 \text{ kg steam}$$

are to be disposed of in driving the steam engines or turbines in the central station. With this quantity of steam, turbines can generate about 6000 H.P and steam engines about 8150 H.P., which can be utilised for the provision of power for driving the pit and factory and also for the disposal of rubbish.

If in place of the poppet-valve presses ordinary slide-valve presses are installed, calculation shows up the power available in the central station in a much less favourable light The drying steam used per hour remains the same, as also does the steam used in the boiler feed pumps and the leakage losses. But the steam used in the presses amounts to at least

30 kg. per I H P

For 2750 I H.P this works out to

$$2750 \times 30 = \text{about } 82,000 \text{ kg}$$

Taking into consideration the steam used for the boiler feed pumps, etc , there remains

$$140,000 - (82,000 + 20,000) = 38,000 \text{ kg steam}$$

for driving the machines in the central station

Steam turbines can generate about 2500 I H P and steam engines about 3450 I.H.P. from this quantity of steam Therefore, by the installation of poppet valve presses an excess of power of 6000 - 2500 = 3500 or 8150 – 3450 = 5000 I.H P. is obtained

With this amount of energy the whole of the rubbish of all the works of

[1] The new plant consists of two large briquette factories and an intermediate central station It was partially finished in the year 1908

the Ilse Bergbau Akt Ges can be removed electrically, so that all steam power can be dispensed with

It is now perfectly obvious how advantages accrue to the whole brown-coal industry by the electrical operation of the rubbish removal and other subsidiary operations, when not only the power machines of the central station but also the briquette presses are worked as economically as possible since in this case the power costs practically nothing

II Production of Steam[1]

Simple Lancashire boilers, each tube having 80 to 110 sq metres of heating surface, are generally utilised for the generation of steam At the Ilse briquette factory however, the Steinmuller tubular boiler of 355 sq metre (including 88 sq metres of superheating surface) has been installed in place of the Lancashire boiler, principally in order to provide the necessary quantities of high-pressure steam to the central electric station after the weekly or other stoppages of operations, and also in order to economise space by increasing the total heating surface of the boiler plant without enlarging the boiler house They are partially operated by the semi gas firing of Keilmann & Voelker, Bernburg

The double tube boiler plant with Topf mechanical stoker and superheater, illustrated by figs 225 to 227, is an example of a well-arranged installation giving good results Such a one is to be found at the Clara pit briquette factory III, owned by the "Eintracht" brown coal mines and briquette factories, Neu-Welzow, Lower Lausitz. The same firm has equipped the boiler plants at their older factories with the efficient appliances of J A Topf & Sohne, Erfurt

The boiler plant consists of ten Lancashire boilers each of 90 sq metres heating surface, and serves for the hourly generation of 27,000 kg steam at 10 atms super-pressure for the above briquette factory, equipped with six large steam table driers, 6(+1) presses, for a production of 50 to 53 D.W of briquettes in 24 hours It also provides steam for the daily delivery of about 22,000 hl crude coal from the open workings and also for a small pumping plant

The more or less coarse, woody, and impure furnace or boiler coal (see p. 320 *et seq* and p 339) sorted from the briquetting coal in the wet operations passes by way of a band conveyor into the coal store (see pp 345 to 346) immediately above the stoke-hole, from which it rolls automatically to the furnace. In

[1] "The Rational Utilisation of Brown Coal in Steam Raising," *Z Braunkohle*, 1905, No. 35, figs. 231-234

order to be able to regulate or interrupt this operation easily, the Topf dampers are arranged above the furnaces so as to be easily set in operation from the attendant's stage by means of the projecting hand-grips (fig. 226). The Topf regulator, charger, or stepped-grate furnaces are provided with very effective appliances for the regulation of the burning fuel and the admission of air. The grates (for each boiler) are chosen so large that a consumption of 33 kg. per sq. metre per hour can easily be dealt with. Ash-removal channels

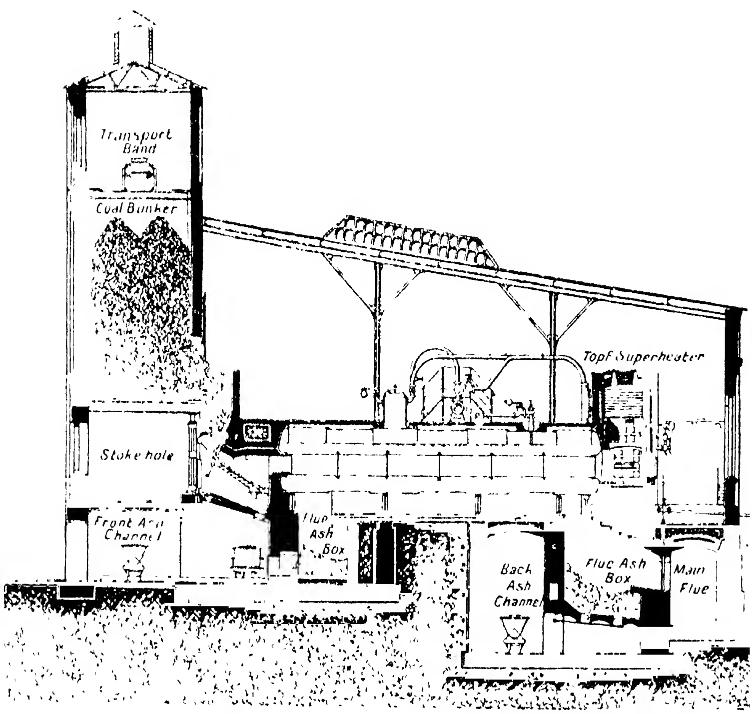


FIG. 225. - Lancashire boiler plant with Topf mechanical charges and Topf superheater.

below the stoke-hole, together with the side channels, permit of the stoke holes being kept free from dust and fumes.

The Topf superheater deviates from the usual form of superheater inasmuch as the steam from each pair of boilers passes through a common apparatus provided with twenty-six zigzag tubes and having a total heating surface of 38 sq. metres. This is built at the back of the boilers so as to be heated by the waste gases. The wet boiler steam of 10 atms. super-pressure at 183° C. is heated to 250° C., so that it issues from the mains into the steam cylinder perfectly dry.

Care is taken to largely utilise the heat of the gases and to separate the flue ash in ash pockets (with removal channels) by regulation and measurement of the draught (fig. 225).

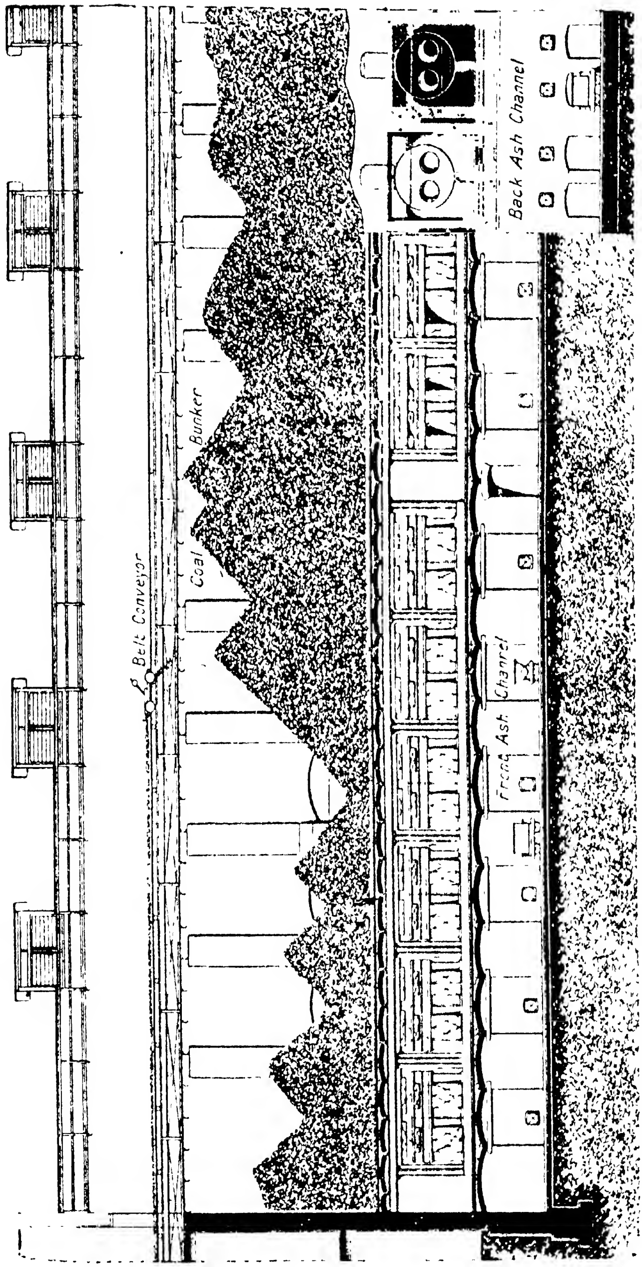


Fig. 226.—Lancashire boiler plant with [illegible] mechanical [illegible]. Longitudinal section through the front and back (right-hand bottom corner) of the boiler house.

The chimney is 65 metres high, and has an internal diameter of 3 metres at the top.

The steam boiler plant is built next to and in the same line as the wet-preparation house of the briquette factory (see p. 559, right of fig. 237). Only a few men are required for attendance in the boiler house.

The whole water and steam economy of briquette factory III. is represented in the flow diagram in fig. 231.

In Section XI. on "Complete Briquette Factories" various other boiler plants are illustrated and briefly described.

Specialities in Briquette Factory Boiler Installations. The numerous greater or lesser differences in the boiler plant and accessories in a brown-coal briquette factory do not come within the scope of this book, and reference will be made only to some specially remarkable appliances.

1. The Haase patent process of burning dust has already been described on pp 486 and 487 (fig. 198).

2. The Frankel system of burning slime dust on trough grates is dealt with on p. 488

3. Flue ash-catchers have recently been introduced at the junction of the main flue with the chimney, particularly in cases where insufficient care is taken to separate the flue dust in the boiler plant itself, and it is carried, often in a glowing state, along with the smoke into the chimney and issues from the top, probably in the form of sparks, to the detriment and danger of the surroundings Of the numerous known systems, the Otto Schumann[1] flue dust-catcher built by the Zeitzer Dampfkesselfabrik & Apparatebauanstalt G. Schumann of Zeitz is one of the proved best and most often applied In general it has already been included in the description of his coal dust-catcher (p. 502, *a*, fig. 208).

4. Heating effect meter, particularly that of the Ados system (Gesellschaft m. b. H. Aachen), combined with regular temperature measurements in the boiler house and flue, provide a continuous automatic control of the firing by chemical testing of the smoke gases for the content of carbonic acid. An inventory of the results is taken every five or six months.

Important Guiding Principle (Prof. Josse) —The loss of heat in the waste gases is directly proportional to their excess of temperature over the boiler-house temperature, and approximately inversely proportional to the carbonic acid content or the initial temperature calculated from this.

[1] *Z Braunkohle*, 1906, iv, No 2, pp 21 25, figs 20 21

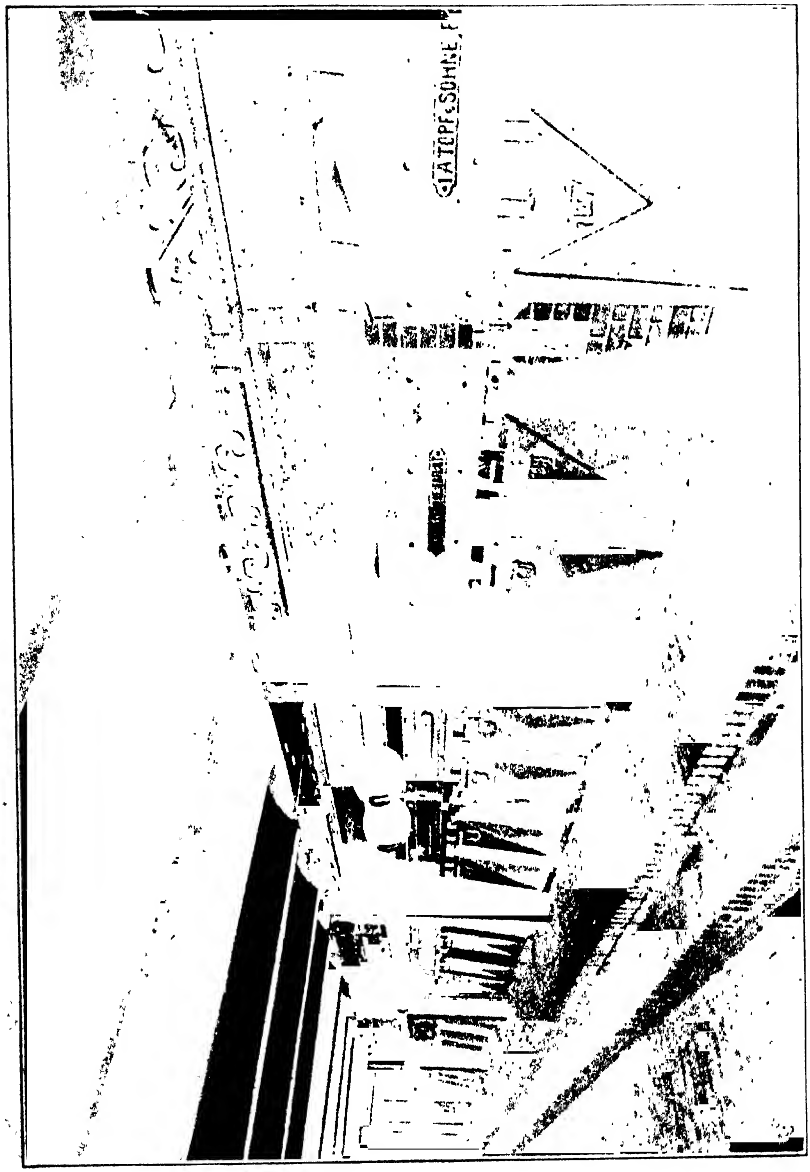


Fig. 227.—Lancashire boiler plant with Topf mechanical stoker. Stoke-hole.

5. Feed-water purifiers are always indispensable to prevent th formation of boiler scale and other stoppages in cases where pit wate or other impure water is used in addition to the condensed water (se below) for feeding the boiler, for tooling and dust extraction. Th choice of suitable purifiers and methods will naturally depend on th particular chemical composition of the water.

Removal of lime, magnesia, iron, sulphuric acid, sodium chloride, etc., presents the main problem. Mechanical impurities are previously settled in clarifying plants or by natural filtration through sand in exhausted open workings (see pp. 521 and 522).

Water purifiers which find considerable application are those of the Maschinenbauanstalt Humboldt, Kalk, near Cologne, Wwe. Joh. Schumacher Maschinen- & Armaturenfabrik, Cologne (lime-soda method); Hans Reisert, Cologne (sulphuric acid-clay-soda method); L. & C. Steinmuller, Gummersbach, Robert Reichling & Co., Dortmund and Konigshof (regenerative method, soda without common salt), and so on. The feed-water purifiers are usually combined with a preheater which can be heated by means of waste steam or condenser water (see fig 231).

6. *Condensed Water Main.*—Up to the present, means have not been provided for the return of the condensed water from the driers to the steam boiler. Economy demands that the condensate should be returned to the boiler with the lowest possible loss of heat so as to avoid undue burden on the boiler.

Most of the steam traps or return pipes (see figs. 147 and 149) in which the elevation of a copper float periodically opens the steam valve so that the issuing steam produces the same pressure in the trap as in the boiler and causes the condensed water to return to the boiler, usually possess the disadvantage that the rising of the float is not always able to overcome the friction of the steam valve exposed to the boiler pressure, thus often leading to stoppages.

This disadvantage should be overcome by the condensed water return pipe of the Gewerkschaft Sibyllagrube, Frechen.[1]

Recently very successful endeavours have been made to equip duplex steam pumps without fly-wheels, which are generally the most satisfactory for boiler feed pumps, for automatically feeding the condensed water.[2]

For water at higher temperatures, such pumps, made by Weise & Monsky of Halle a. S., are provided with two external plunger stuffing boxes which can be readily overlooked and attended to during operation. At the same time the pumps are provided with valves which are easily accessible. The condensed water flows first into a boiler-shaped collector situated on cast-iron columns above the pump. Here it is subject to the full pressure, and is connected to the pump through a simple pipe, and operates the steam valve of the pump by

[1] *Z. Braunkohle*, iii., 1905, No. 4, pp. 54–55, figs. 21–24

[2] *Ibid.*, vii., 1909, No. 48, p. 832, fig. 313.

means of a float. Such a plant can, if necessity arises, be used for cold water feeding without alteration.

Feed-Water Preheaters (economisers), a structure of narrow tubes, built in the flue of the boiler plant, through which the water circulates and is heated by the hot gases on their way to the chimney. Such an appliance is not very common in briquette factories.

The preheating surface is very much cheaper than an equal heating surface in the boiler, so that such a preheater, which can generally be included in the boiler plant with ease, is especially to be recommended in cases where there is excessive work on the existing boiler and the installation of a new one is impossible on economical or other grounds. At the same time, the excess of heat in the burnt gases is at least partially utilised. In brown coal firing particular notice must be taken of the fact that such an apparatus always causes the local separation of much flue dust.

III. Steam Superheating. Removal of Oil from the Exhaust Steam.

Steam superheaters in the shape of systems of narrow tubes which, like the Topf apparatus (pp. 541–542, fig 225), take up the steam from single, neighbouring, or a whole series of boilers and heat it up by means of the hot gases playing round the tube system, now find almost universal application in brown-coal briquette factories, mainly, however, with the object of evaporating the mechanically suspended particles of water in the wet steam, causing it to enter the cylinders of the presses and motive engines in the "dry" state so that there is no detrimental condensation. Superheating is usually carried only to 220° or 250° C., and 300° C. at the very outside. There is no object to be gained in the use of superheated steam for the drying of coal, a point which has been dealt with in detail on pp. 365–366.

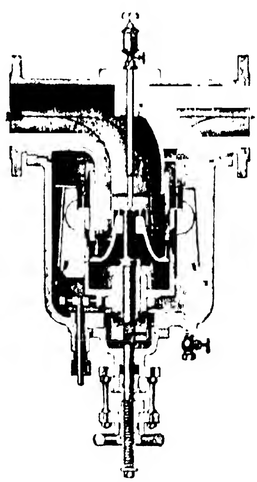


Fig. 228.—Scheibe patent oil extractor for waste steam

Removal of Oil from the Exhaust Steam.—The importance of removing oil from the exhaust of the presses, etc., before introducing the steam into the drier has already been dealt with on p. 367. Of the various oil-separating systems, the Scheibe patent oil extractor of R. Scheibe & Sohne, Leipzig (fig. 228), is one of the most effective and most generally applied

It consists of a centrifugal apparatus arranged in the waste steam pipe of the press house, the particles of cylinder oil together with the whole of the other foreign bodies in the steam being flung to the inner wall of the rapidly rotating conical drum down which the oil slides and flows through an opening in the bottom, to be recovered as lubricating oil, while the purified steam issues from the top of the drum into the pipe at the right.

Other well-known systems of oil extractors are those of Hans Reisert, Cologne, Kinneth & Knoebel, Magdeburg, etc.

IV. Water and Steam Economy of a Large Briquette Factory.

The flow diagram, fig. 231 (p. 550) gives a review of the steam and water used in the large Briquette Factory III connected with the open working of the Clara mine at Neu Welzow, Lower Lausitz, and erected in 1904 and 1905.

B. POWER PLANT—ENGINES AND MOTORS.

As examples of the power plants of briquette factories, those of the Akt.-Ges. Lauchhammer and the Braunschweigischen Kohlenwerke Akt.-Ges. will now be described briefly.

1. *Power Installation of the Lauchhammer Briquette Factory*

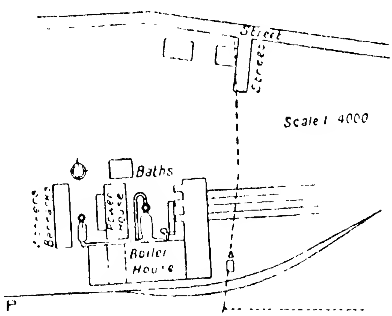


FIG. 229.—Ground plan of the briquette factory and the power installation of the Akt.-Ges. Lauchhammer, Lower Lausitz.

(Figs. 229, 230, 232, 233, and 234.)—In addition to their briquette factory built in 1904, which has already been dealt with repeatedly (p. 317, fig. 117, p. 323, fig. 119, p. 413, fig. 155), the Akt.-Ges. Lauchhammer is in possession of a large-power installation[1] (electric central station) whose position can be seen from fig. 229. The current

[1] "Der elektrische Kraftbetrieb der Braunkohlenbrikettfabrik der Akt.-Ges. Lauchhammer," Krumbiegel, *Z. Elektrische Kraftbetriebe und Bahnen*, 1907, No. 5, figs. 91–97.

generated (two-phase alternating of fifty cycles) is utilised for driving the briquette factory itself as well as for operating the bridge and engine works, the iron foundry, the enamel works, the bronze foundry, and the cutting mills of the Lauchhammer works

In the power plant (fig 230) there are installed —1 vertical twin non-condensing engine, coupled directly to a 700 K.W. dynamo (ex-

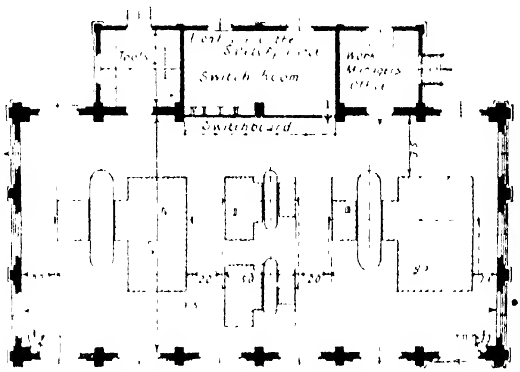


Fig. 230 Ground plan of the Lauchhammer briquette factory power plant

ternally rotating commutator A E G). 2 small compound condensing engines coupled to dynamos of 170 K W., and, in reserve, 1 vertical compound condensing engine with dynamo of 700 K.W Altogether, therefore, 1750 K W can be produced

All the motors of over 10 K.W capacity installed in these factories are fed directly with high tension current (2 × 1130 volt), which is, however, stepped down to 2 × 170 volts for the smaller motors For illumination, only the two outer conductors, whose voltage is diminished to 120 by a transformer, are employed

The driving steam required is used exclusively for the production of electrical energy. Generated in fourteen Lancashire boilers each having a heating surface of 95 sq metres, the steam at a pressure of 8·5 atms above atmospheric, and at 250 C., passes on the one hand to the 6 briquette presses, taking about 750 I H P , but on the other hand the major portion passes to the twin engines in the power plant Here its pressure is reduced to about 2·5 atms (above atmospheric), when it passes on to the 6 tube driers (p 113, fig. 155), in order to warm them to the temperature necessary for drying

The quantity of steam used in the twin engines is dependent on the weight and nature of the coal to be dried, and is therefore subject to considerable variations For the necessary purposes of equalisation, the pressure of the waste steam is kept constant at all times, and the amount of steam taken from the twin engine is regulated by operating the steam engine regulator (Fischinger system) on the switchboard (fig. 232), a procedure which is greatly to the

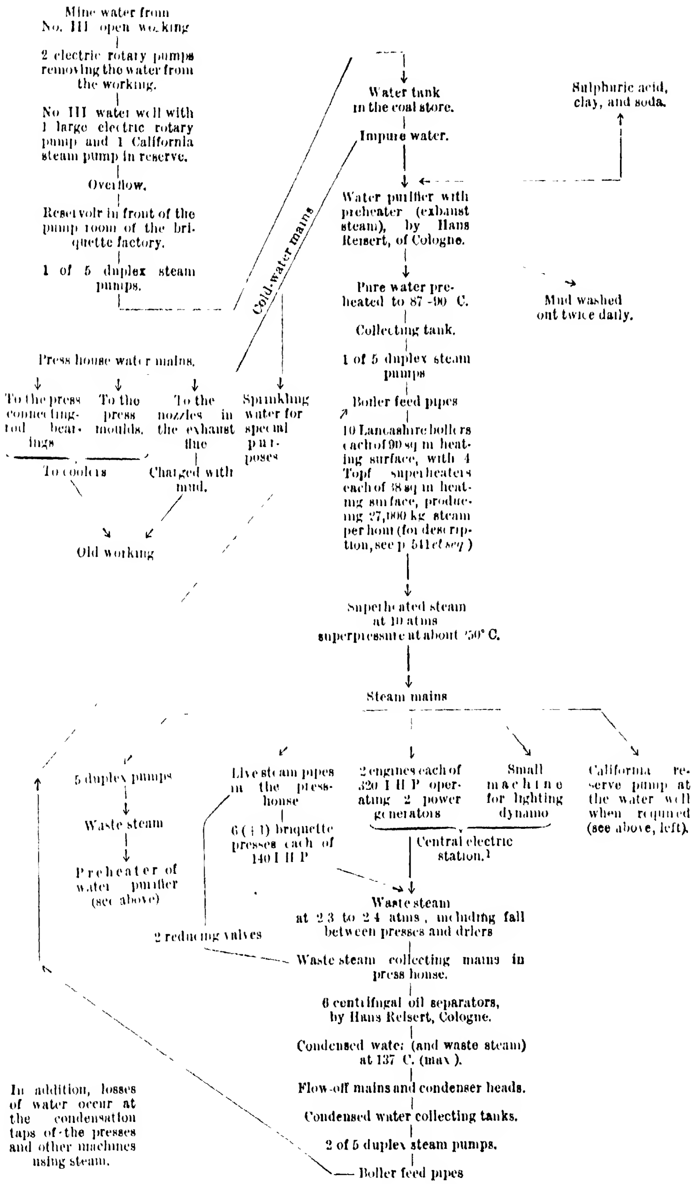


FIG. 231.—Flow diagram of the water and steam in the Clara Mine Briquette Factory III. at Neu Welzow, Lower Lausitz.

[1] The generators and motors of the central power station are shown on p. 557.

advantage of the whole process of drying. The balance of the electrical energy required is always covered by a small condensation machine (with Porter regulator), which therefore provides a sort of buffer engine. This method of regulation has proved to be very good.

A very uniform current pressure is obtained quite automatically by means of a Tirrill regulator which, by alternately opening and closing a contact breaker, influences the subsidiary current and consequently the main supply. The influence of the Tirrill regulator can be well seen from the autographic voltage curve shown in fig. 233.

The cost of production of electrical energy is uncommonly low. The heat used is only about 800 cals. per I.H.P.

If 1000 cals. can be produced for 0·2 pf. under the special circumstances existing at the briquette factory,

$$1 \text{ K.W. hr. costs about } \frac{0{\cdot}800 \times 0{\cdot}2}{6{\cdot}85 \times 0{\cdot}90 \times 0{\cdot}736} = 0{\cdot}285 \text{ pf}$$

This works out to approximately 0·29 pf. for fuel, a value which cannot be approached by the best combustion engines.

In the briquette factory, power is transmitted by electric motors (Siemens & Halske, Union Allgemeine Elektricitatsgesellschaft) as far as possible, except in the case of the presses. Altogether there are thirty-six motors, with a nominal horse power of about 500. In addition there are three motors each of 50 H.P. and one of 30 H.P. for dealing with the water in the mine. The remaining workshops of the Akt.-Ges. Lauchhammer (see above) are operated with single motors.

Heat Diagram of the Lauchhammer Briquette Factory. (Fig 235.)—The instructive diagram, which needs no explanation, has been drawn up on the basis of the regular measurements of the feed water (condensed and fresh water) made in January 1908, and on the earlier accurate experiments of chief-engineer Krumbiegel.

Comparison with a diagram drawn up several years earlier showed that the crude coal could only contain about 52 per cent. water, whereas previously it had contained 58 per cent. Actual experiments on the crude coal itself showed a content of 52·5 per cent. This shows that even in such a variable operation as is carried on in a briquette factory it is possible to obtain reliable specific average values.

2. The new steam turbine plant of the Braunschweigischen Kohlenwerke, Helmstedt,[1] at the Treue pit, Offleben, provides the mines and briquette factories with electrical energy in addition to supplying the surrounding large factories. In view of the distance which the current has to be transmitted, the generators develop three-phase alternating current at 5000 to 5800 volts.

[1] Described by Emil Snell, Berlin, *X. Allgem. deutschen Bergmannstag zu Eisenach*, 1907.

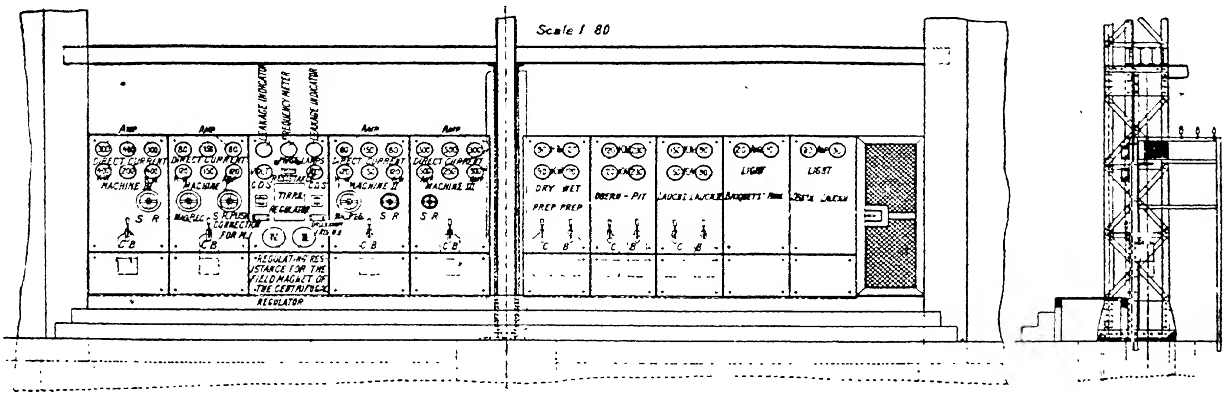


FIG. 232.—Distribution board in the Lauchhammer briquette factory power house.

S R shunt regulator. C B circuit breaker. C O S change-over switch.

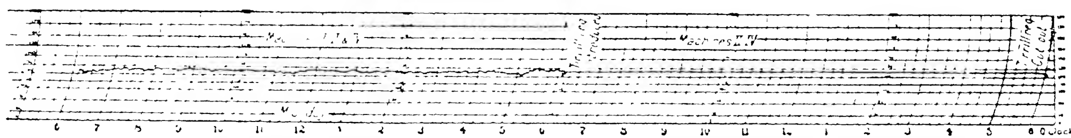


FIG. 233.—Influence of the Tirrill regulator on the voltage curve. Lauchhammer power house.

Originally the steam turbine plant included three turbo-alternators of Brown Boveri Parsons design —

2, each of 750 K.W. corresponding to 1100 H.P. at 3000 revs. per min.
1, „ 1800 „ „ 2050 „ 1500 „ „

After complete equipment the power plant will contain five turbo-alternators with a total output of 8500 H.P. Each turbo-alternator consists of a steam turbine, a rotatory generator, and an exciting machine whose shafts are immediately connected. Each set of machines is provided with its own special condensing plant, so that the waste steam is not used in drying in this case.

The costs per kilowatt hour, including all direct charges and a proportion of the liquidation (about 6½ per cent. on the boiler, 7½ per cent. on the machines, and 10 per cent. on the electrical part), amount to 3 to 4 pf.

3. The power plant of the Ilse Bergbau Akt.-Ges., Lower Lausitz,[1] was discussed on pp. 539–540.

4. *Combined or Single Drive of the Appliances in a Briquette Factory (excluding the Presses).* Whilst previously the mechanical appliances for the wet preparation, the dry operations, and the conveyance of the coal were operated from two driving machines in the engine room by means of belt transmission, the drive has recently been effected by single motors, usually electric motors, arranged as closely as possible to the machine, which practice is generally increasing.

The use of single drive obviates the considerable expenditure of power in a complicated transmission, even under no load. Further, the working appliances can be combined in any predetermined manner, or only a few of them may be operated without increasing the friction losses which always exist in a plant operated by ordinary transmission. Again, any irregularities in running can be recognised at the outset if each motor be provided with a switchboard and an ammeter. Each appliance can also be worked at the speed best suited to the prevailing conditions, whereas with an ordinary transmission drive such regulation is only possible—at best indifferently—by means of cone pulleys (pp. 387–389, and p. 412). Nevertheless, the common transmission drive, in which only two large machines need attention, is still preferred by the managements of a number of works.

Fig. 236 shows a section through the steam cylinder of a modern economically running steam engine, provided with the approved Lentz system of positive valve gearing (*cf.* p. 458). The exhaust steam is applied to the drying of the coal.

[1] The older power plant is described in *Z. Glückauf*, Essen, 1897, No. 7.

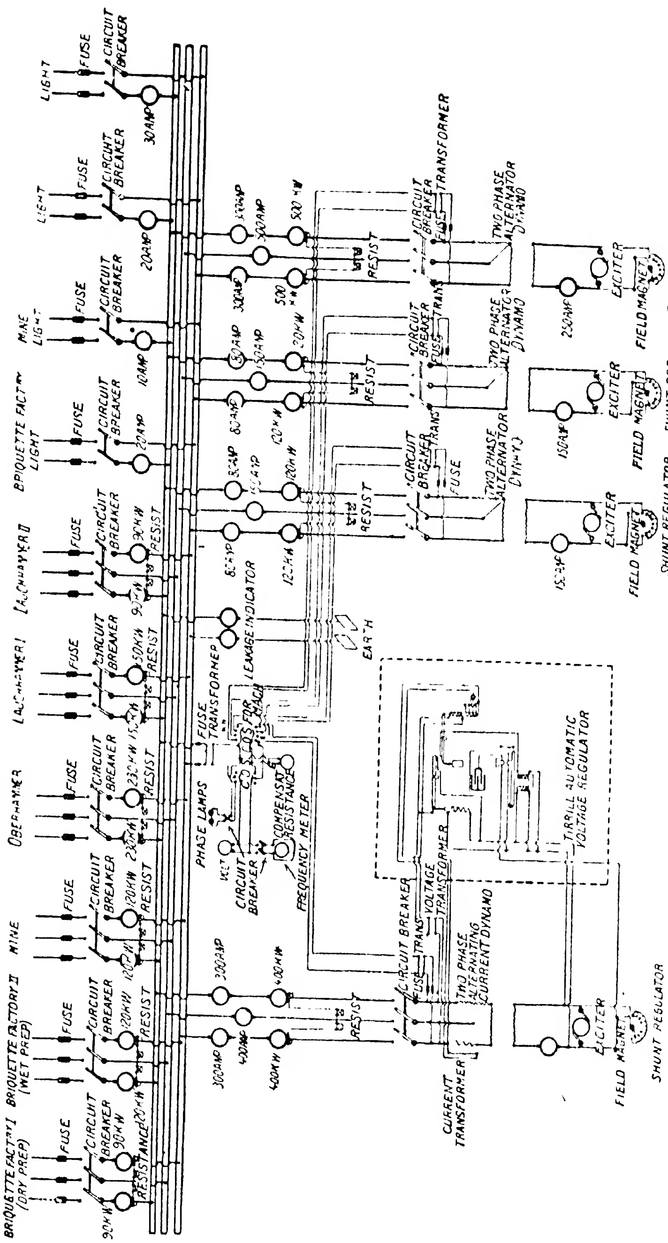


FIG. 234.—Distribution scheme of the Lauchhammer briquette factory power plant.

This, or similar valve engines, also finds application for driving electrical power generators.

Typical examples of the widely applied single drive by electric

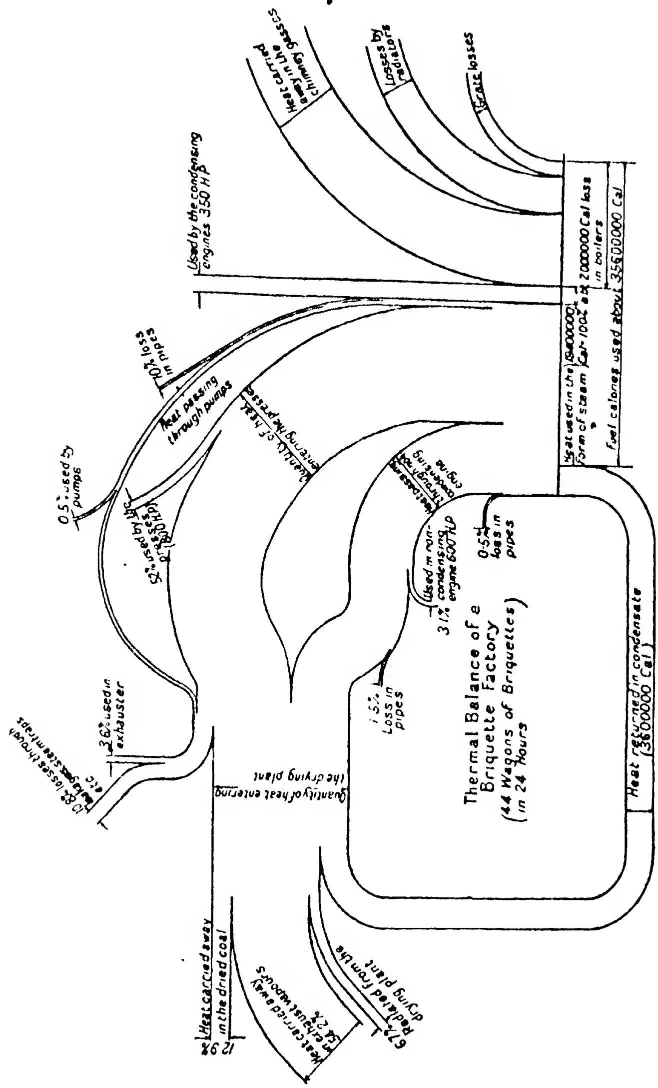


FIG. 235.—Heat diagram of the Lauchhammer briquette factory (spring 1905. (According to Krumbiegel.)

motors are provided by the Lauchhammer briquette factory, the Briquette Factory III. of the Clara mine, and others. Details of the electric stations and motors of the latter are reproduced below.

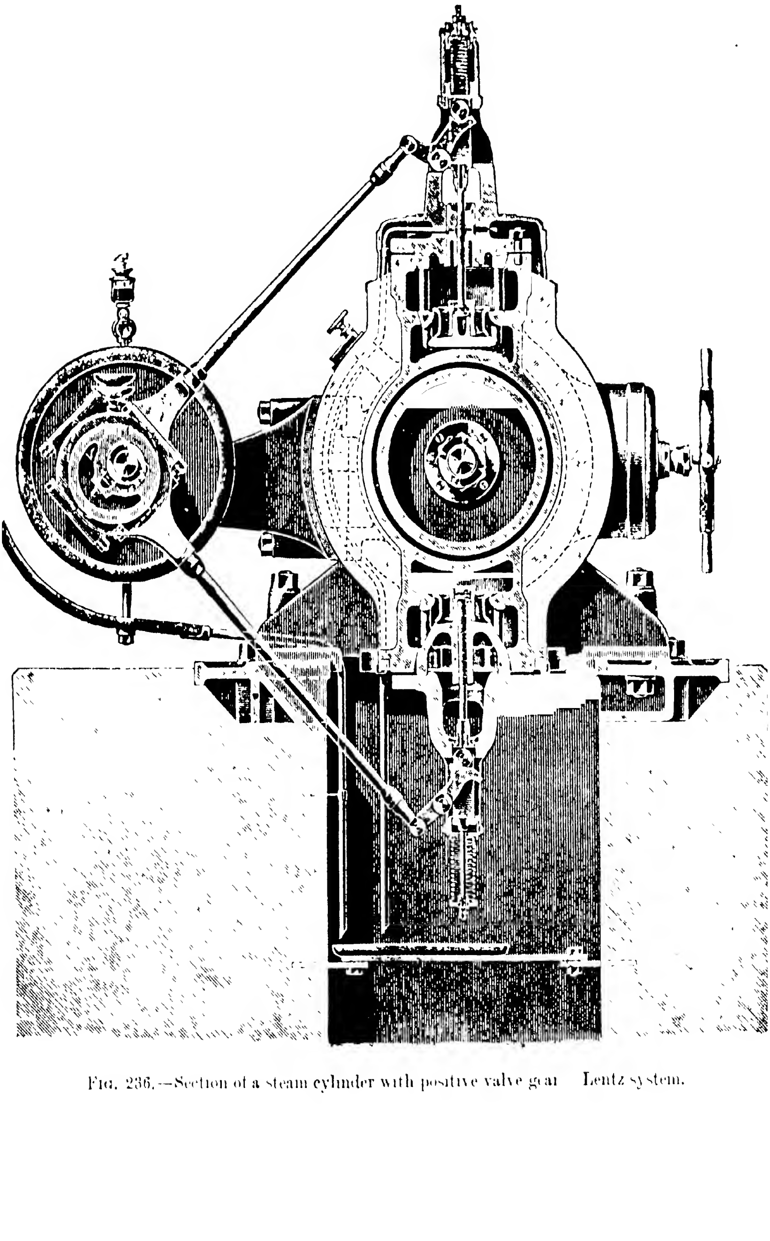


FIG. 236.—Section of a steam cylinder with positive valve gear Lentz system.

ELECTRIC STATIONS OF THE BRIKETTFABRIK III., GRUBE [illegible], NEU [illegible], AND THE MOTORS OPERATED FROM THEM

No. of Pieces	E.M.F.	Description of Machine	Built for a Normal Output of: Singly	Built for a Normal Output of: Together	Load in Operation: Singly	Load in Operation: Together	Applied for	Price: Singly	Price: Together
	volts							marks	marks
				CENTRAL ELECTRIC STATION					
2	500-520	Dynamo	225 K.W.	450 K.W.	140 K.W.	280 K.W.	Driving motors	17,000	34,000
1	110	"		30 "		[illegible] "	Illumination		1,[illegible]00
3	Total current produced			480 K.W.		[illegible] K.W.			[illegible]500
				MOTORS FOR THE BRIQUETTE FACTORY III					
1	500	Motor		50 H.P.		[illegible] H.P.	Preliminary crushing		[illegible]700
1	"	"		25 "		23 "	Elevator		[illegible]910
[illegible]	"		40 H.P.	[illegible] "	[illegible] H.P.	[illegible] "	Wet preparation	[illegible]	[illegible]
1	"	"		[illegible] "		3	Crude coal band		[illegible]
1	"	"		[illegible]		[illegible] "	Boiler coal elevator		[illegible]
1				[illegible] "		3 "	Boiler coal band		[illegible]
1	"			7 "		5 "	Coal store band		[illegible]
[illegible]	"		10 H.P.	60 "	7 H.P.	[illegible]	Table oven stirrer [1]	[illegible]	[illegible]
1	"	"		15		[illegible]	Worm conveyor drive in oven and press house		1,[illegible]
1	"	"		[illegible] "		11	Dry elevator		[illegible]
1	"			10 "		10 "	Drive of worm in cooling and store room		[illegible]
1	"			[illegible] "		[illegible] "	Draught		[illegible]
1	"			10		6 "	Repair shop and [illegible] room		[illegible]
1	110		[illegible] K.W.	[illegible] "		[illegible] "	Driving air pump to blow dust out of the motor		[illegible]
21		Total motors		311 H.P.		[illegible] H.P.		Total	[illegible]
				MOTORS FOR OPERATING THE MINES					
1	500	Motor		40 H.P.		[illegible] H.P.	Chainway for the Factory III		[illegible]
2	"		10 H.P.	20	7 H.P.	14	Rotary pumps in Open Working III	[illegible]	[illegible]
1	480			[illegible]		[illegible]	Larger rotary pump in Shaft III		[illegible]
1	"			30 "		12	Chainway for Factory I		
1	500			17 "		12	Rotary pump for Shaft I		1,[illegible]
1	480			[illegible] "		[illegible]	Chainway for Factory II		
1	500			[illegible] "		18 "	Rotary pump for Shaft II		[illegible]
8		Total motors		214 H.P.		146 H.P.		Total	19,[illegible]

[1] These motors have been briefly described on p. 389

SECTION X.

COMPLETE BROWN-COAL BRIQUETTE FACTORIES.

1. *Briquette Factory III., Clara Mine, Neu Welzow, Lower Lausitz, with Six Steam Table Driers, Seven Presses, Electrical Station, and Single Drive.* Output = 50 – 53 D.W.[1] per 24 hours. (Fig 237.)—Proprietors. The Aktiengesellschaft Eintrachtwerke, Braunkohlenwerke und Brikettfabriken, Neu Welzow. Year of erection · 1904-05. The machinery was obtained from the Zeitzer Eisengieszerei & Maschinenbau Akt.-Ges. and the electric motors from the Siemens Schuckert-Werke. Fig. 237 shows a front view of the factory. At the right is the coal store of the boiler house (below), which has been described previously (p. 541, figs. 225 to 227), in the centre is the wet-preparation house (above); and at the left the dry-preparation and press house, provided with six exhaust chimneys. The drying, cooling, and store houses are connected to this at right angles. The small shop standing by itself contains the repair shop, the forge, the grinding shop, material stores, and the offices for the engineer and briquette manager. The numerous wooden beams standing to the left and right are destined to carry the briquette gutters leading from the ground floor of the main building on the left to the loading sheds and track 140 metres away (not visible in the picture).

The crude coal obtained daily in the open workings of Factory III. (3600 waggons of 6 hl. = 21,600 hl. daily) is brought from the right by means of a chain on an iron bridge behind the coal store of the boiler house to the wet preparation, where it is dressed and sorted into about ¾ briquette coal and ¼ boiler coal. The briquette coal contains 57 to 58 per cent. water, which is reduced by drying to 15 per cent. for domestic briquettes and 17 to 18 per cent. for industrial briquettes (cubes and nuts). The brand of briquettes is "Anker." Six steam table driers are to be found in the upper story (high windows in the building to the left), above the press house, whose heat

[1] D.W. = double load = 10 tons + 1·5 per cent. (150 kg.) overweight.

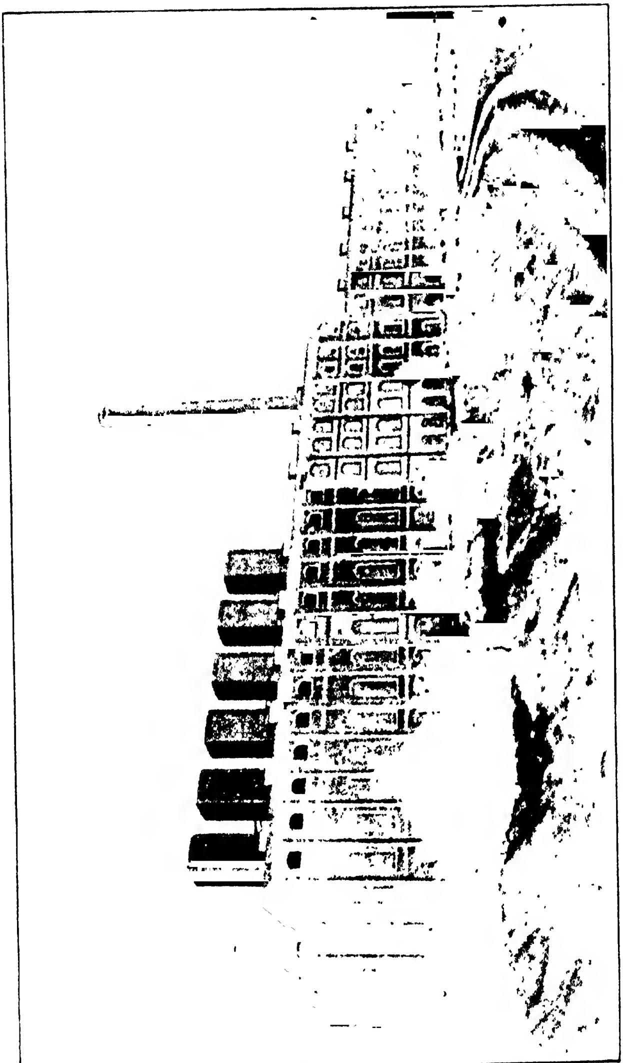


FIG. 237.—Briquette Factory III, Clara mine, of Neu Welzow, Lower Lusatia, with [illegible] steam tanks, drums and seven presses.

passes into the driers through holes in the ceiling. After cooling, the dried coal passes through coolers (p. 428) in an adjoining building to the Zeitz presses at a temperature of about 30° C. The presses are each of about 140 H.P. are provided with precision piston-valve gearing, and make 130 to 140 strokes per minute. Dust extraction is combined dry or wet.

The central electric station, feed water purifier, and the five duplex steam pumps are arranged in buildings at the back; the remainder is indicated in the diagram, fig. 231, and the table on p. 557.

2. *Briquette Factory with Six Steam Table Driers and Six Presses, Electric Station, and Single Drive.* Daily output up to 48 D.W. (Plate VI.)—This plant, also constructed by the Zeitzer Eisengieszerei, differs from the previous one mainly in that the dry preparation and the press rooms are not arranged one above the other, but behind one another on the ground floor of the oven or press house (see p. 391).

Wet-Preparation House.—To the left is a boiler coal system (supply hopper *a t* with roll crusher, chute *r*, and elevator *e*), at the right (plan and section C D) three similar briquette coal systems each with one supply hopper *a t* with supply and crushing rolls *a w*, shaking sieve *s s*, disintegrator *d*, chutes *r r*, and elevator *e*. The band conveyor *f b* distributes the briquetting coal over the coal cellar in the oven house.

The six steam table driers T situated below are each driven by an electric motor. While the vapours escape through the chimneys Bs, the dried coal passes by means of the worm conveyors *f s e h* of the dry elevator *e* (plan and section E F) and an upper worm to the store rooms of the press house (section G H), and from thence to the charging hoppers of the six presses P by means of the worm conveyors below.

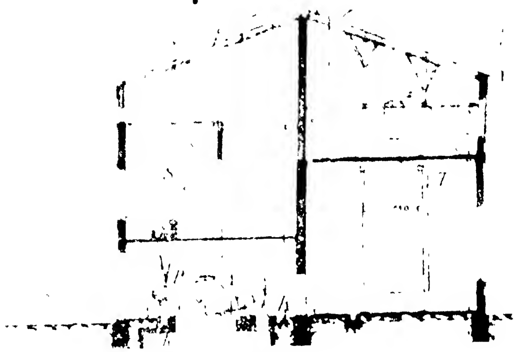
The stamp dust is sucked through a channel K by an exhauster E (plan), also connected to the upper worm conveyors, to the exhaust chambers, to which the waste from the condenser taps of the press cylinders also flows through a second channel K.

In the engine house there are three single-cylinder steam engines of equal size, together with dynamos and one small engine for a lighting dynamo.

3. *Lauchhammer Briquette Factory, Lower Lausitz, equipped with Six Tube Driers, Six Presses, Central Electric Station, and Single Drive.* Daily output (24 hrs.) = 45 to 46 D.W.—For the conditions existing and the equipment of this factory, erected in 1904,[1] see p. 317,

[1] *Z. Glückauf*, Essen, 1903, No. 35. The output of 300 tons cited here has lately been increased to the above amount.

PLATE VI



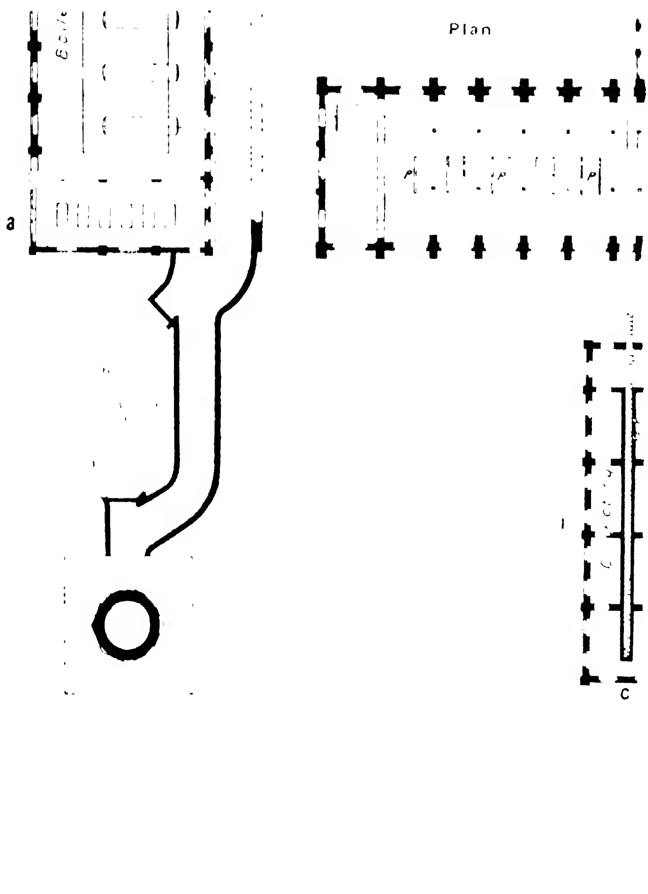

Plan
a
c

fig. 117, p. 323 fig. 119, p. 413 fig. 155, p. 521 fig. 218 (view), and pp. 548 *et seq.* figs. 229 230 232 235 (plan and power installation).

A portion of the machinery and the whole of the constructional ironwork were provided by the Akt. Ges. Lauchhammer themselves, while the remaining machinery was provided by the Maschinenfabrik Buckau. A very effective dust extraction is carried out by a combined dry and wet method (with spray nozzles), the Haase combustion method is utilised for internal dust extraction.

4. *Eva Mine Briquette Factory, Lower Lausitz, with Ten Tube Driers, Ten Presses, Electric Central and Transmission Drive.* Output per 24 hrs. = 70 D.W. (Plate VII.) The open working and conveyance of crude coal (with 58 per cent. water) to the Eva briquette factory and the neighbouring Renate factory is described on pp. 312 to 316 and illustrated by figs. 115 and 116. Both belong to the Ilse Bergbauaktiengesellschaft, the Eva factory having been built by the Maschinenfabrik Buckau in 1904. Its equipment is obvious from Plate VII.

The wet preparation and engine shops adjoin one another in a rear building, the dry-preparation and press shops are situated in the front building, divided symmetrically by a narrow staircase in the centre, while the driving motor house is situated between the two buildings. Parallel to the cross axis of the fore building runs the store house, which in addition to the housing of the worm conveyors serves the purposes of cooling. The boiler house is placed at the side and at the present time contains ten Steinmüller tube boilers and six steam pumps. A flue dust catcher is indicated at the side of the flue from the boiler house to the chimney.

About 320 hl. briquettes and 115 hl. boiler coal are required for the production of 1 D.W. briquettes. Drying is effected by the similar current system; dust extraction is combined.

The central electric station in the engine room consists of two vertical steam engines each of 450 H.P. (from the Maschinenbau Akt.-Ges. Paul Swiderski, Leipzig), with two Siemens & Halske rotary generators. In the driving room (see plan) there are four motors of equal size, one each for the wet preparation and dry preparation (Plate VII., right, section *c d*), the others being in reserve. In the repair shop and forge (not illustrated) single drive is used. The central station also provides current for the chain conveyance and the pumping plant.

Management, superintendence and working of the factory are

carried out by one briquette manager, foremen for the day and night shifts over the wet preparation, dry preparation, and loading, one overlooker in the boiler house (day shift), and 125 workmen (partly day partly night shift).

5. *"Dora and Helene" Briquette Factory at Gross-Zössen in the Leipzig District. Equipped with (ultimately) Twelve Tube Driers, Twelve Presses, Slime-filtering Plant, and Central Station.* Output in 24 hours about 85 D.W. (Plate VIII.)—This briquette factory, belonging to the Duxer Kohlenverein of Teplitz, was built by the Zeitzer Eisengieszerei in 1907, and equipped with nine tube driers, seven presses, and twelve steam boilers. Plate VIII. depicts it as it is ultimately intended to be. It resembles the briquette factory III. of the Clara mine (p. 558, fig. 237) with regard to the housing of the various main branches of the work in a single long building divided into sections. It differs from that factory, however, in that the dry-preparation and press rooms adjoin each other on the ground floor, somewhat resembling the factory illustrated in Plate VI.

Wet Preparation.—The whole of the crude coal (with the exception of the boiler coal, which is of little value) is brought by the chain conveyor discharging at the front, and is first subjected to a preliminary crushing by means of a rotatory tipper, a coarse roll crusher, and shaking sieve (section C D). The boiler coal is thrown into a tipper in front and carried to the boiler house by an inclined band conveyor, while the preliminarily crushed coal is carried to the two systems on the right and the three systems on the left by means of a horizontal belt. Pulverising is then completed by means of centrifugal mills (section G-H). The fine coal is carried upwards by wet elevators and thrown on to a shaking sieve, and the briquetting coal falling through passes to the coal cellar (plan and section L-M) by way of the inner band conveyor. Coarse lumps, etc., passing over the sieve are carried towards the left by the band conveyor at the back (plan) and on to one of the two cross bands, either for delivery to the boiler coal belt or to the belt travelling to the wet-preparation plant situated behind the briquette factory and not shown on the plate. Unsorted crude coal can also be sent to the wet-compression plant by means of special tippers on the left side of the wet-preparation store.

Drying in the tube driers is effected on the principle of similar currents. The dry coal passes through hoppers and downcomers (section C-D) to the oven worm conveyor, is carried to the elevator at the right, and thence to the cooling and store room (plan and sections

R-S, A-B, N-O, and P-Q). The arrangement and use of these rooms, especially those fitted with inclined plate coolers, has already been described (pp. 428 430).

Finally, the cooled and thoroughly mixed coal is carried to the press house by means of the worm conveyor running alongside, and rendered readily accessible by means of an iron footbridge and is distributed into the charging hoppers of the presses (plan and sections R-S, A-B, and L-M). Excess of coal is delivered at the end of the conveyor into another worm placed at right angles on the wall, and is returned to the oven worm conveyor, and so on. The press house is amply lighted by many large windows and lights in the iron-constructed roof. Heat coming from the presses and steam pipes is turned to account in drying the coal through the intermediary of the air drawn into the upper front end of the tube drum. The system of dust extraction is a combined one. The water flowing from the vapour chimney (section C-D) is pumped from a collecting tank to the distributing tank of a Zeitz slimes filtering plant (not shown) by means of a rotatory pump. The filtration plant contains for alternate use three filter chambers each with five frames and one enclosing cover stretched with filter cloth. In the filter chamber the slimes are first filtered under the pressure of the column of water above. After closing the entrance valve more water is pressed out of the thickened slime under a steam pressure of 2 atms., after which the cover is opened the slime cake removed and scraped off into a collecting hopper, from whence it is removed to the coal store of the boiler house by means of a band conveyor and an elevator.

The mechanical appliances of the briquette factory and filter plant are partially operated by means of large electric motors with transmission drive and partially by small electric motors.

6. *Briquette Factory of the Robert Mine at Wansleben,*[1] *with Two Combined Tube and Table Driers, Two Separate Systems of Exhaust-Dust Extraction, Two Presses, and Transmission Drive.* Daily output = 12 D.W. (Plate IX.)—The plant, intended for four systems of driers and presses, but originally only carried out in the above capacity, was built in 1903-4 by the Bernburger Maschinenfabrik, Bernburg, for the A. Riebeckschen Montanwerke Akt.-Ges. as a result of an order of the existing Royal Mining Board to the effect that the preliminary drying of crude coal (with about 60 per cent. water) up to the commencement of dust formation (at about 30 per cent. water) must be effected in

[1] *Z. Braunkohle*, iii., 1904, No. 17, pp. 225-227. Gertner's Monograph, pp. 58-59.

short tube drums, but the finished drying must, however, be effected in low table ovens.

Wet Preparation.—The coal obtained during the day from the Furstenberg shaft of the Robert deep mine is carried by a chain conveyor to the second story of the wet-preparation house situated on the left (plan and section E–F) and delivered to one of the two wet-preparation systems consisting of rotatory tipper, supply hopper with crushing rolls, first shaking sieve, centrifugal mill, second shaking sieve, chutes, band conveyor, elevator A for the briquette coal, and band conveyor Z and elevator Z' for the boiler coal. The briquette coal is elevated to the upper story and distributed by the band conveyor above the coal store of the dry-preparation and press house (longitudinal section A–B).

The arrangement of the drying plant has already been briefly described on pp. 417–418. Each tube drier C has a heating surface of 448 sq. metres, revolves at 4·14 revolutions per minute, works at a steam pressure of 1·5 atms., and deals with 72·5 hl. coal per hour, which, after lumpy portions have been broken by the roll crusher H, is completely dried in the table oven D below, under a steam pressure of 0·8 to 1 atm. Generation of dust is diminished by means of inclined downcomers between the tables.

The dried coal passes by the worm conveyors T, U, and V through the downcomer into the store and collecting room W (longitudinal section A–B, plan, and section E–F) and then to the two presses by means of the conveyor M (section C–D).

The dust chamber E with the downcomer F (section C–D) and a water spray and steam jet (in a common chimney G) serve for the extraction of the dust from the vapour of the tube drier C. The vapours from the table oven are first passed through a dust chamber Kl attached to each oven under the suction action of the fan N (1500 mm. diameter, Schiele system) in order to remove coarse particles, which are then conveyed to the press hopper conveyor M by means of the cross worm conveyor L (plan and section I–K).

The fine particles, however, are drawn off by the fan through the pipes O_1 and blown tangentially into a Boreas P. Any dust precipitated here is removed by means of a stirrer and downcomer into the worm conveyor Q and from this into the press hopper worm M (section G–H), while the finest particles pass with the vapours from the Boreas through the pipe R into the chimney S, where dust is precipitated by means of fine water sprays and steam jets.

The internal dust extraction is connected to the exhaust extraction of the table drier by means of the pipe O. The stamp dust from the presses, however, is passed through a worm and a special small propellor fan to a dust chamber system full of water and situated externally.

All the dust not compressed is passed to the boiler firing. In the engine room (to the left at the front, plan and section E F) there is a single-cylinder engine of 110 H.P. for the wet and dry preparations and an engine of 30 H.P. for the lighting dynamo feeding 126 incandescent and 8 arc lamps.

The boiler house (not visible) contains four Lancashire boilers each of 100 sq. metre heating surface obtained from the Zeitzer Eisengiesserei.

The total costs of the installation were:

I.	Factory buildings, boiler house, chimney and bridge conveyor from the Fürstenberg shaft	175 000 marks
II.	Internal equipment of factory (excluding III.)	250 000 „
III.	Electric lighting and signal appliances	12 000 „
IV.	Boiler feed pumps, water and steam pipes	13 000 „
V.	Erection costs and sundries	75 000 „
	Total	525 000 marks

More detailed accounts of complete brown coal briquette factories are given in the following section.

SECTION XI.

ECONOMICS OF BROWN-COAL BRIQUETTING COST SHEETS.

THE remarks made with regard to the economical results of briquetting pit coals, pp. 221–222, apply equally well to brown coals. In addition the following factors have to be taken into account —

A. SIZE OF THE FACTORY PLANT.

As a rule, the economy or profits of briquetting, assuming a good market, increase with the size and output. The modern practice therefore is to build larger or increase the size of existing factories. There are a fair number of briquette factories with ten to twelve presses and an output of 70 to over 80 D.W. in twenty-four hours, more especially in the Lower Lausitz and Lower Rhenish districts. Many firms have fourteen or even more presses collected in one works, but here the number exceeds the limit which can be worked with convenience.

The more extensive a brown-coal briquette factory is, the more complicated, difficult, and tedious it becomes for the managers responsible to exercise control over the numerous engines and appliances running both day and night, and to remedy the inevitable stoppages and to superintend the work of the employees. At the same time, the greater is the danger to which the plant and staff are exposed, owing to fires and explosions consequent upon conflagrations not having been discovered at the proper time, although these dangers have been considerably diminished in modern factories by the recent regulations of mining authorities. The necessary safety, however, is only assured by means of a series of measures which are carried out daily and properly overlooked during working or during pauses in the operations.

Consequently, ten to twelve presses (with the necessary wet-preparation, dry-preparation, and dust-extraction plants) should not be

exceeded except in cases of extreme necessity. It is far better to limit the number of presses in each factory to six or eight at the most, and to obtain the desired production of a large output of briquettes at several medium-sized factories arranged close together so that they can be provided with power from a common central electric station. Such medium-sized factories, whose output varies from 36 to 56 D.W. daily, can be superintended quite easily by an able briquette manager, and with an engineer and the necessary workmen can be worked in a certain and economical manner, thus ensuring the greatest possibility of profit.

B. CRUDE COAL REQUIREMENTS AND SIZE OF THE COAL-FIELD.

The determination of the quantity to be produced or the output of the factory is primarily dependent on the existence of standing stocks of brown coal, which are easy to get and to briquette, and secondly, on the market conditions. In the interests of large profits it is advisable to acquire as early as possible a coal-field which is large and rich enough to keep at least a medium-sized briquette factory in operation for a long series of years. K. Kegel[1] has drawn up in a very capable manner a review of the sizes of coal-fields to supply the needs of at least twenty-five years.

The crude coal required for the production of a ton of brown-coal briquettes amounts to between 2·2 and 3·5 ton, an average of approximately 3 tons, of which ⅔ to ¾ is briquette coal and ⅓ to ¼ is boiler coal.

This relationship varies in different districts and even in the same works, according to the nature—especially the water content—of the crude brown coal, and should be continually controlled by accurate determinations made at regular intervals of time. The figures given by the works are generally only estimates, are expressed in hectolitres, and worked out to 1 Zentner (50 kg.) of briquettes. The following are some examples:—

CRUDE COAL REQUIRED PER ZENTNER OF BRIQUETTES.

At	Briquette Coal.	Boiler Coal.	Total.
	hl.	hl.	hl.
Briquette Factory III., Treue Mine	1·228	0·317	1·599
,, ,, Clara ,,	1·2	0·6	1·8
,, ,, Bismarck ,,	1·5	0·3	1·8
,, ,, Victoria ,,	1·32	0·63	1·95
,, ,, Eva ,,	1·6	0·575	2·175

[1] *Z. Braunkohle*, vii., 1909, No. 49, p. 851.

The weight of 1 hl. crude coal averages about 73 kg., and varies between 68 and 77 kg. according to the water content, density, and ratio of lump, coarse, and fine coal. A 1. cubic metre heap of crude brown coal = 14 to 15 hl.

Economy demands the maximum reduction in the boiler coal used,—by efficient firing (see p. 541 *et seq.*), by the maximum utilisation of the heat generated (see p. 360 *et seq.*, 367, 393 *et seq.*, 414 *et seq.*, 502–503, 555), by economical use of steam in the presses and engines (see p. 456 *et seq.*, 531 *et seq.*, 549, and 553), and further, by preventing the loss of material in the form of dust or slimes (see pp. 171–173, 184 *et seq.*, and 514–521).

Stock of Coal required.—With a press output of 60 tons per 24 hours = 300 × 60 = 18,000 tons yearly, an average of 3 × 18,000 = 54,000 tons of crude coal are required for each press per year. A briquette factory with seven presses therefore requires about 378,000 tons of crude brown coal per annum = equal to 9,450,000 tons of available coal in the twenty-five years.

With a coal seam 10 metres in thickness the amount of coal obtainable from 1 hectare would be:—

(*a*) In the case of open working, assuming a working loss of 10 per cent. (at the boundaries, on the bottom, etc.) = 10,000 × 10 × 0·9 = 90,000 tons.

(*b*) In the case of deep working, assuming a working loss of 35 per cent. 10,000 × 10 × 0·65 = 65,000 tons, taking it that 1 cubic metre weighs 1 ton.

The size of the coal-field required for the above-mentioned seven-press factory must therefore amount to at least:—

$$(a)\ \frac{9,450,000}{90,000} = 105 \text{ hectare if an open working,}$$

and

$$(b)\ \frac{9,450,000}{65,000} = 145{\cdot}4 \text{ hectare if a deep working.}$$

C. COST OF THE CRUDE COAL.

This is also of the greatest importance in the economy of briquetting. It makes a considerable difference whether, as for example in the district subject to the mandate of the former Elector of Saxony,[1] the rights of disposal of the brown coal are in the hands of the ground landlord, or whether, as in the remaining parts of Prussia, such rights are not at the disposal of the landlord.

[1] Decree of February 22, 1869, concerning the rights of coal and brown-coal mining in those parts of the country subject to the electoral mandate of August 19, 1743.

In the district governed by the mandate mentioned, the mine proprietor either acquires the real estate with its coal supplies, or takes a separate right of mining from the ground landlord in return for a fixed purchase sum or ground rent per ton and immediately becomes burdened with high net costs, more especially when he has to provide interest and liquidate for a considerable purchase sum.

At a purchase price of 4000 marks for the mining right over 1 hectare, which has often been paid for a coal seam considerably less than 10 metres in thickness, the total cost in the above case (*a*) would be 105 × 4000 = 420,000 marks, and in (*b*) 145.4 × 4000 = 581,600 marks. If the whole ground rights are acquired, prices of 8000, 10,000, 12,000, and even 14,000 marks per hectare are not extraordinary, particularly for a rich mine. However, in the area governed by the general Prussian mining laws of June 24, 1865 (with later additions), respecting the freedom of mining brown coal, a field up to 2,200,000 sq. metres (220 ha.) in area can be applied for and allotted merely on description of the discovery (§ 27). But, in consequence of par. 148, the lessee of the mine is compelled to provide complete compensation for all damage suffered by the property or its belongings as a result of subterranean mining or open workings.

Further, the costs are considerably influenced by the methods of getting, the thickness and condition of strata of the soil covering and the coal, and may be very different according as the coal is obtained under favourable or unfavourable conditions, such as by open working with little soil covering or by deep mining, possibly under great pressure and influx of water and other similar dangers (see p. 307 *et seq.*).

The fact that the net costs of crude brown coals per hectolitre vary between 5 and 25 pf. can be explained by these or other variations which have been previously described. Average conditions correspond to about 10 to 15 pf. per hectolitre. At works with net mine costs of less than 10 pf. it is not unusual to fix the charge for the crude coal to the briquette factory at 10 pf.

D. INSTALLATION COSTS OF BRIQUETTE FACTORIES.

1. *Summary of Estimate of Costs for the mechanical equipment of a Brown-Coal Briquette Factory with two presses and two steam table driers*, three coolers, dust-extraction and dust-filtering plant, for an output of 11 D.W. domestic or 12 D.W. industrial briquettes in 24 working hours. The water content of the crude coal varies up to 60 per cent., while the buildings are adapted for three wet-preparation plants, four driers, six coolers, and four presses.

No.	Objects.	Total Price.
	(a) Steam Plant.	
		Marks.
4	Lancashire boilers each of 115 sq. metres, bricked in, with all accessories, steam superheater, and accumulator	49,140
1	Collecting boiler for the condenser water	2,200
2	Complete hot water duplex feed pumps	4,200
2	" cold-water " "	3,700
	Total (a)	59,240
	(b) Wet Preparation Plant.	
3	Rotary tippers (hand operated) for briquette and boiler coals (2 in the boiler house)	1,025
4	2 supply and projection rolls, 1 toothed roll, and 1 smooth roll crusher	8,100
3	Jolting sieves with accessories	3,750
2	1 fine coal and 1 chip elevator with brick tower	1,300
4	Band conveyors for fine coal, and chips	6,900
	Chutes, small hoppers, and sundries	6,000
	Total (b)	30,075
	(c) Dry Preparation and Dust Extraction Plant.	
2	Steam table driers with 32 plates and all accessories	86,000
1	Dust extractor with dust chutes, gutters, jets, sludge pipes, doors, ventilation pipes, explosion doors, etc.	5,650
	Total (c)	91,650
	(d) Cooling and Store Room Plant.	
	Worm conveyors below the driers, to the cooling and store room, for emptying the store room, to the press charging hoppers	9,900
1	Dry coal elevator with brickwork tower	2,900
2	Metal slide coolers, each with 102 cooling plates	4,500
	Iron parts, sheet metal work, and covers in the cooling and store room	7,950
	Total (d)	25,250
	(e) Press Installation.	
2	Briquette presses of the strongest type, with expansion valve gear and all accessories	40,370
	Stock of parts of the press die.—1 cooling mould (850 M.), 8 short case hardened mould sections (up to 13 M.), 8 short and 4 long steel mould sections (at 22 and 50 M.), 4 steel bars (at 11 M.), 6 hard steel press stamps (at 20 M.), with other accessories	5,154 ?
500	Metre briquette gutters	3,500
	Total (e)	49,024
	(f) Sludge Filter and Internal Dust-Extraction Plant.	
1	Double section sludge filter plant of Zeitzer design, with accessories	20,000
1	Dust extractor and burner (Haase patent)	10,000
	Total (f)	30,000

No.	Objects.	Total Price.
	(a) Engines and Accessories	
2	Horizontal steam engines (diameter of cylinder = 400 mm., stroke 500 mm.) with precision piston valve gear for operating the wet and dry operations, etc.	15,400
1	Horizontal steam engine (280 mm. diameter, 400 mm. stroke), for electric lighting	3,600
	Transmission shafts, bearings, etc., driving pulleys, pipe lines and accessories, oil extractors from steam, water tanks, all iron constructional parts, sheet metal roofs, etc., roof lights, iron doors, windows, stairs, etc.	143,460
	Sum (e)	162,460
	Total (a) to (e)	447,699
	Cost of the installation (6 per cent. of the calculated amount (444,299 M.))	26,701
	Total cost of the mechanical appliances[1]	474,400
	In addition.—Costs of the factory building, foundations, and chimneys, about	185,000
	Freight charges and sundries	14,000
	Total cost of installation	673,400

2. *Expenses of a Briquette Factory with two presses, two tube driers,* two plate coolers, combined exhaust dust extraction, steam jet exhauster plant, and four steam boilers each of 115 sq. metres heating surface for a maximum output of 12 D.W. industrial and domestic briquettes per 24 hours. The water content of the crude coal = 56 per cent.

The pipes, shafts, elevators, and band conveyors are so proportioned that they could serve a four-press plant, but in the case of such an enlargement it would first be necessary to increase the size of the boiler house, oven, and press shop to a corresponding extent.

Mechanical plant, including installation		304,000	marks[3]
Buildings, with foundations and chimney		126,000	„
Freightage and sundries		15,000	„
	Total	445,000	marks

3. *Expenses of a Briquette Factory with four presses, four tube driers,* four plate coolers, seven steam boilers each of 107 sq. metres heating surface, remainder of equipment as per 2 for 24 D.W.

[1] Without freightage; f.o.r. at Zeitz station.

[2] Taking into consideration the estimate provided for the future extension to a four-press plant.

[3] According to a special Zeitz estimate in 1908.

industrial and domestic briquettes per 24 hours. Water content of crude coal = 58 per cent.

Machinery and installation	508,300 marks[1]
Buildings, including foundations and chimney	185,000 „
Freightage and sundries	16,700 „
Total	710,000 marks

4. *Costs of a Briquette Factory with seven presses, seven tube driers*, six inclined shelf coolers, complete dust-extraction plant, two large briquette scales, completely equipped workshop, five waggons, two principal and one bye-tracks, chain driven, one chain-conveyor bridge, etc., for 42 D.W. domestic briquettes per 24 hours. Water content of the crude coal = 57 per cent. (max.).

Machinery and installation	1,349,000 marks[2]
Buildings, including foundations and chimney	451 000 „
Freight and sundries	40,000 „
Total	1,840,000 marks

5. *Costs of a Briquette Factory with twelve presses, fourteen tube driers*, twelve inclined shelf coolers, combined exhaust dust extractor, Beth filter plant for internal dust extraction, twenty-two steam boilers each of 115 sq metres heating surface, four steam engines for electric lighting and driving the chain tracks, two lighting dynamos, chain conveyor-equipment with bridge repair shop, forge equipment, etc., for an output up to 76 D.W. domestic briquettes per 24 hours.

Machinery	1,970,300 marks[3]
Equipment (6 per cent. of 1 970,300 marks)	118,200 „
Buildings with foundations and chimney	565,000 „
Freight and sundries	56,500 „
Total	2,710,000 marks

From these summaries and the costs of the Robert briquette factory dealt with on p. 565 it appears that the cost of a plant varies between 180,000 and 260,000 marks per briquette press according to the disposition and special equipment of the factory. In the Rhine district the cost of installation is taken as between 200,000 and 250,000 marks per briquette press, which stands in fair agreement with the above.

[1] According to a Zeitz special estimate in 1908.
[2] According to a Zeitz special estimate in 1908.
[3] According to the Maschinenfabrik Buckau estimate in 1906.

The excessive sum given in estimate 1 is accounted for by the fact that provisions have been made for a future enlargement to a four-press plant.

Consequently, the costs of installation of brown-coal briquette factories are relatively high.

E. COSTS OF PRODUCTION

1. *Net Working Costs* for a two-press briquette factory producing 12 D.W. briquettes in 24 hours = 300 (25 × 12) D.W. monthly.

Estimate of Costs.[1]			Monthly.	Per ton of briquettes.
			M.	M.
1. Interest on and liquidation of [illegible]				
(a) Interest, 5 per cent. on 445,000 M.			1,8[illegible]	1.60
(b) Liquidation: 10 per cent. of [illegible],000 M. [illegible]				
working apparatus			[illegible]	
5 per cent. of 180,000 M. [illegible]			7[illegible]	
2. Crude brown coals:				
(a) Briquette coal (24 [illegible]				3.00
(b) Boiler [illegible] 12				1.[illegible]0
Total 36 [illegible]				
Equal to a monthly [illegible] 36 [illegible]			13,[illegible]	
3. Employees' wages per 24 hours [illegible]				
2 engine attendants each at	5 marks	7 marks		
2 boiler ,,	3[illegible]	[illegible]		
1 ash remover at	3	3		
3 wet preparation attendants [illegible]	[illegible]	10		
8 oven[illegible]	[illegible]	[illegible]		
2 pressmen	[illegible]	[illegible]		
1 grinder machine [illegible]	[illegible]	[illegible]		
12 youths for loading and [illegible]	[illegible]	[illegible]		
31 men at a total [illegible] M. [illegible]			2[illegible]	[illegible]
2 foremen, 1 weighman: each at a salary of 200 M.			[illegible]	
4. Lubricating [illegible] and [illegible] material			[illegible]	0.2[illegible]
5. Repairs, replacements and [illegible]			[illegible]2	0.1[illegible]
Total			1[illegible]90	7.50

From this it appears that the pure working costs amount to 7.5 marks per ton or 75 marks per D.W. of briquettes. The figures correspond approximately to average working. Their magnitude is principally determined by the costs of the crude brown coal, a fact shown more clearly in Table I below.

Consequently, the costs of coal amount to between 55 and 70 per cent. of the total working costs, so that there is every encouragement for the briquette factory to obtain its coal as cheaply as possible and to be as economical as possible in its use (see pp. 567–568).

[1] Estimate No. 2 is used in the above.

TABLE I.

Cost of the Crude Brown Coal per Hectolitre.	10 Pf.	12·5 Pf.	15 Pf.	20 Pf.
	M.	M.	M.	M.
Cost of coal (36 hl.) per ton of briquettes	3·60	4·50	5·40	7·20
Net working costs per ton of briquettes	6·60	7·50	8·40	10·20

The manufacturing costs are obtained from the net working costs simply by subtracting the costs of the briquetting coal. In this way is obtained:—

TABLE II.

Cost of Crude Coal per Hectolitre.	10 Pf.	12·5 Pf.	15 Pf.	20 Pf.
	M.	M.	M.	M.
Manufacturing costs per ton briquettes, inclusive of interest and liquidation	4·20	4·50	4·80	5·40
Manufacturing costs per ton briquettes apart from interest and liquidation	2·60	2·90	3·20	3·80

In the above example there is an item of 0·98 mark per ton as wages for a staff of thirty-four men, which is absolutely essential, and particularly at the rate of wages paid at the present time in the Rhine district.

If the wages per shift are, for example, 3 marks and 1·8 marks (instead of 3·5 and 2·5 marks), and the salaries 175 marks (instead of 200 marks), the total wages are diminished to 0·8 mark per ton of briquettes, representing a reduction of 18 pf.

Considerable economies in wages may be effected by considerably enlarging the plant and increasing the production of briquettes, since the capabilities of the staff and workmen are utilised to a far greater extent.

Obviously, a rigid economy is desired in the materials so long as no disadvantage arises to the moving parts and machinery thereby, such as would be the case by the application of a cheap inferior lubricating oil, which easily becomes acid and has a very deleterious effect on the life of the machine. The value of an efficient method of oil removal from the steam, which at the same time provides as complete a recovery as possible with subsequent use of the cylinder lubricating oil, has already been shown on p. 367.

Staff of a Twelve-Press Factory.—A twelve-press factory in the Lower Lausitz, with a daily output of about seven times that of the above two-press factory employing 34 men, has a staff of 12[illegible]

which is only 3·7 times that of the previous case. The staff is distributed somewhat as follows:—

Day and Night Shifts (a–f).		Additional.
(a) Wet preparation —	(d) Boiler house	(g) Loading
2 soft coal handlers.	4 coal fillers	Day shift 30 women and youths.
18 other workmen	6 stokers	Night shift 20 loaders over 16 years of age.
2 foremen.	2 feeders	Day and night shifts —
(b) Dry preparation:—	1 chief stoker	2 locomotive drivers
4 oven fillers in the coal store	(e) Engine room —	2 shunter
6 oven attendants	6 engine attendants for the engines and in the power house	2 loading foremen
2 cooler attendants	(f) Repair shop	
2 worm conveyor attendants	1 foreman	1 mine inspector to manage the open working and the briquette factory
2 foremen.	2 grinder	
(c) Press house. —	1 mechanic	
12 pressers		
4 press die fitters		

The costs of repairs and replacement parts, particularly for the steam table driers, worm conveyors, press dies, and stamps, must be limited as much as possible by careful tidy working, selection of the most suitable materials for the parts subjected to wear, superior methods, and by carrying out the repair work effectively (compare pp. 381, 405–406, 423–424, 444–445, and 449 *et seq.*). The total material costs are then reduced below the above estimates in not a few works.

For the costs of dust extraction see pp. 514–515 and 521.

II. *Total Net Costs.*—There are still to be added to the working costs:—

6. The works share of the general staff of the briquette factory.

7. The share of the general costs (management, general management, rates and taxes, etc.) which fall to the factory.

If the amounts for 6 and 7 combined (for the above two-press factory) be taken as 0·50 mark, which is on the high side, the total net costs per ton of briquettes works out at 7·50 + 0·50 = 8·00 marks.

Table III. below shows the relation between the total net costs and the crude coal costs given in Table I., other factors being equal.

TABLE III.

Cost of Crude Brown Coal per hl	10 Pf.	12·5 Pf.	15 Pf.	20 Pf.
	M.	M.	M.	M.
Net costs per ton of briquettes	7·10	8·00	8·90	10·70
D.W. „	71	80	89	107

These figures refer to a small plant which had not been placed in a favourable position at the beginning, and which only permitted of moderate profits under conditions of low coal costs and high selling prices for briquettes. Large, well-equipped briquette factories working economically can produce briquettes at about 65 marks per D.W., particularly if they have a supply of very cheap coal.

F. INCOME AND PROFITS.

The income and profits of a briquette factory are obviously dependent in the highest degree on the selling price.

In the various brown-coal districts of Germany by far the greater proportion of the works have combined sooner or later to form briquette-selling syndicates with the object of selling the whole of their outputs at certain fixed prices per D.W. (10 tons) f.o.r. at the nearest stations, with certain variations for differences in quality and freightage.

From 1900 to 1906 the prices generally amounted to:—

- In the brown-coal district of Central Germany, between 82 and 92 marks per D.W.
- In the brown-coal district of the Rhine, between 85 and 105 marks per D.W.

From 1907 to 1908 the large commercial prices varied—

- For domestic briquettes, between about 95 and 108 marks per D.W.
- For industrial briquettes (cubes and nuts) between about 85 and 95 marks per D.W.

This considerable difference in price is brought about by the fact that the industrial briquettes are made from coal subjected to much less drying, requiring less steam, and not making so great a demand on the boiler. Further, as compared with domestic briquettes, the industrial cubes and nuts are enabled to make much better use of the section of the press mould.

At an average selling price of	100 marks per D.W. domestic briquettes,	
and a net cost of	80 ,, ,, ,, ,,	
the profit amounts to . .	20 marks per D.W. domestic briquettes,	

so that a yearly production of $300 \times 12 = 3600$ D.W. provides a net profit of 72,000 marks, which is equal to 16 per cent. on the costs of installation (445,000 marks), and which, moreover, has been made for about 6·2 years.

With crude coal costing 15 pf. per hectolitre and net costs of 89

marks per D.W. briquettes (Table III.), the profits would fall to 11 marks per D.W., or 39,000 marks yearly, but still providing a yield of 8·76 per cent.

On the other hand, large flourishing works with net costs at about 65 marks and a selling price of 100 marks permit of making a profit of about 35 marks per D.W., which, for example in a seven-press factory with a yearly output of 50 × 25 × 12 = 15,000 D.W. and costing about 1,575,000 marks, makes a yearly income of about 525,000 marks, and provides a profit of about 33 per cent.

Prominent notice should be given to the fact that in good times such firms have always applied quite considerable proportions of their yearly profits to the welfare of their employees and to other useful objects.

SECTION XII.

STATISTICS. APPLICATION OF BROWN-COAL BRIQUETTES.

A. STATISTICS OF BROWN-COAL BRIQUETTING.

EXHAUSTIVE statistics of brown-coal briquettes similar to those given for pit-coal briquettes in Part I., p. 235 *et seq.*, will not be given here, since they have already been dealt with very exhaustively in several recent publications,[1] especially as concerns the two most important districts, viz. the Halle Mining Commission district and the Bonn Mining Commission district, particularly the Bruhl-Unkel Mining region, which has been divided into the East and West Cologne districts since 1908. The author limits himself therefore to a few important figures and reviews.

1. GERMAN EMPIRE.

Reference should first be made to the table "Coal Supplies and Briquette Production of the German Empire in the years 1901 to 1907," contained on pp. vi-vii of the Introduction to this book, and also to fig. 2 (diagrams, etc.).

The figures in the column "Briquettes and Wet-Compressed Blocks"

[1] Collected works, *Die deutsche Braunkohlenindustrie*, 1907, III. Economics Section, by S. Beisert, p. 115 *et seq.*, further, II. Main Section, "Die mechanische Aufbereitung der Braunkohle," by Richter, p. 69 *et seq.* *Die Entwicklung der rheinischen Braunkohlenindustrie und ihre Bedeutung für die Hausbrandversorgung der westlichen und südlichen Deutschland*, by H. E. Böker (Glückauf, Essen, 1908, Nos. 34 to 38). See also *Z. f. d. Berg-, H.-, u. S.-Wesen i. Pr. St.*, Statistics part. *Jahrbuch der deutschen Braunkohlen-, Steinkohlen- und Kali-Industrie* (published by Wilhelm Knapp, Halle a. S.) contains a list of the German brown coal and coal pits, wet-compression and briquette factories, etc., with data regarding production, working arrangements, and installation, as well as the addresses of the directors and officials—*Polters Kalender für Kohleninteressenten* (Dresden, Gerhard Kuhtmann); *Berg.- und Huttenkalender* (Essen, G. D. Baedeker); *Jahrbuch f. d. Berg.- u. H.-Wesen in Kgr. Sachsen* (Freiberg); *Nachrichten für Handel und Industrie.*

refer exclusively to brown-coal briquettes produced in the Halle, Hessia, Sachsen-Altenberg, Brunswick districts, and very largely to brown-coal briquettes with considerably less wet-compressed blocks in the Bonn district. The development of the brown coal briquetting in the two main districts Halle and Bonn is depicted diagrammatically in fig. 238, which shows at a glance the enormous steady increase of briquette production and at the same time gives the number of presses. In the Halle district is shown the division into the Frankfort a. O. (including the Lower Lausitz, West and East Cottbus districts) and Merseburg. A few examples follow.

1. *Briquetting in the Halle Mining Commission District in 1906.* Of the total sales of brown coal (36,071,299 tons) in the district during 1906:—

30.98 per cent. was sold as crude coal,
43.73 „ worked up to briquettes,
1.73 „ wet pressed blocks,
3.12 „ in distillation plants,
20.44 „ used for firing, and a small quantity (270 tons) was worked up to hand pressed blocks.

	Quantity of Briquettes produced	Coal used per ton of Briquette: Briquette Coal	Coal used per ton of Briquette: Boiler Coal	Coal used per ton of Briquette: Total	Number of Presses	Average Output per Press per Year
	tons	tons	tons	tons		tons.
Frankfort district	3,998,776					
Merseburg „	2,600,419					...
Magdeburg „	482,740					
Whole Halle district	7,081,935	2.23	0.82	3.05	543	13,042

Concerning the size of the industry, the various factories produced:—

1 works (Clara) with 21 presses in three factories, over 300,000 tons (334,232 tons).
6 works each with 10 to 14 presses in one or two factories, between 200,000 and 300,000 tons.
14 works each with 7 to 13 presses, between 100,000 and 200,000 tons.
36 „ „ 4 „ 9 „ „ 50,000 „ 100,000 „
22 „ „ 25,000 „ 50,000 „
18 „ „ 10,000 „ 25,000 „
10 „ below 10,000 tons.

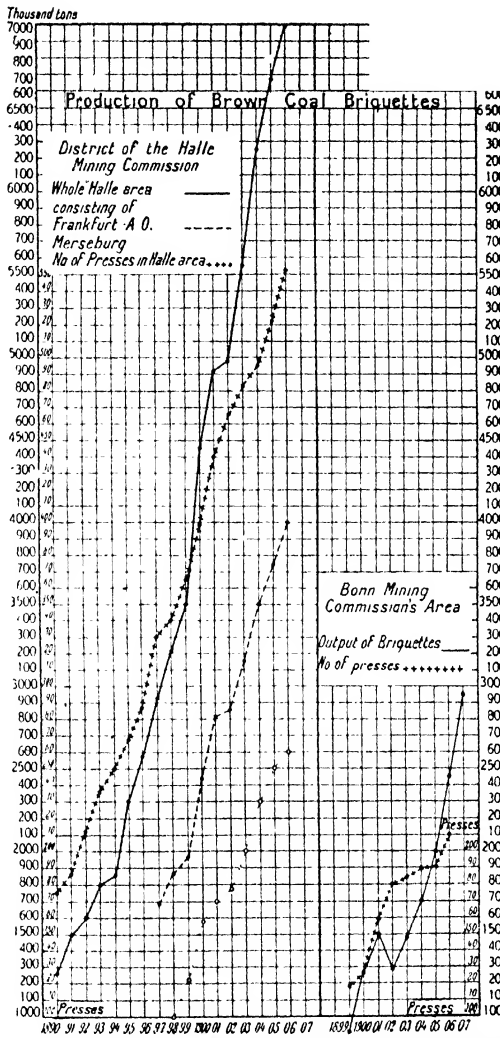


FIG. 238.—Diagrams showing the development of the brown-coal briquette product of Halle and Bonn mining districts in the years 1890 to 1907 and 1899 to 1[907] respectively.

The maximum average output per press in the year 1906 was attained by the Heye pit (Annahutte) West Cottbus district, with 23,878 tons. The principal areas of sale were—Brandenburg province (above all, Berlin), kingdom of Saxony (above all, Dresden), province of Saxony, and the Thuringian States.

2. *Briquetting in the [illegible] Brühl-Unkel Mining District.*

Year.	Crude Coal Supplies	Total Sale of Crude Coal		
		Sold as such	For Briquetting	For Internal Use.
	tons	percentage of supply	percentage of supply	percentage of supply
1906	9,521,437	11·[illegible]	[illegible]7·0	31·7
1907	11,011,[illegible]	10·2	[illegible]8·5	31·4

Year.	Briquette Production	Number of Presses	Average Yearly Output of a Press	Average Briquette Production of a Works	Briquette Sales	
					to Railways	in the Country.
	tons.		tons	tons	tons	tons.
1906	2,108,118	20[illegible]	11,805	68,63[illegible]	[illegible],138,9[illegible]	175,720
1907	2,907,347	[illegible]1	12,[illegible]86	75,2[illegible]4	[illegible],679,565	199,090

Distribution of the Briquette Sales to Railways, in Percentages of the Total Railroad Sales.

Year.	Sale in Germany	Total	Sales in other Countries		
			Holland	Switzerland	Belgium, France, Luxemburg, Austria, Italy, Denmark.
	per cent		per cent	per cent	per cent
1906	83·2	16·8	9·4	1·2	3·2
1907	84·0	16·0	8·6	1·3	3·1

About 50 per cent. of the total sale of briquettes in Germany went to that portion of the Rhine province to the left of the Rhine, about 10 per cent. to the right of the Rhine, while the remainder went to the other N.W. German Provinces and States and to Alsace-Lorraine, the Bavarian Palatinate, and S. Germany.

3. *Review of the Production of Brown-Coal Briquettes (including Wet-Compressed Blocks) in the German Empire during* 1907.[1]

District.	Production of Brown-Coal Briquettes and Wet-Compressed Blocks	Number of Briquette Presses in 1906 or 1907.	Principal Mining Districts or Areas concerned.
	A. Prussia		
	tons		
Halle Mining Commission .	7,709,658	543	East and West Cottbus, Magdeburg, Halberstadt, East and West Halle, Eisleben, Naumburg, Zeitz.
Bonn ,, ,,	3,011,961	207	Bruhl Unkel
Breslau ,, ,,	298,363	about 23	Gorlitz.
Clausthal ,, ,,	89,522	11	Hannover and Kassel.
Total for all Prussia	11,052,507	about 784	...
	B. Other German States.		
Saxon Althenburg	727,625	43	Meuselwitz.
Brunswick. . .	407,880	20	Helmstedt
Kingdom of Saxony	104,068	26	Leipzig mine inspector's district, about 90 per cent.
Anhalt	222,836	18	Dresden mine inspector's district, about 10 per cent.
Grand Duchy of Hesse	75,545	4	
Total	1,837,954	about 111	
Grand total for the empire, sum of A and B	12,890,131	895	

Of this grand total it is estimated approximately that 12,300,000 tons are briquettes and the remainder wet-compressed blocks, since the production of the latter in the previous year (1906) amounted to 583,229 tons. Assuming that the average selling price of briquettes during 1907 was 9.5 marks per ton,[2] the value of the total output of brown-coal briquettes works out to 116,850,000 marks.

Beisert[3] has published a comprehensive list of the various German brown-coal syndicates and briquette-selling agencies.

[1] According to Briquette production in *Nachrichten fur Handel und Industrie.*

[2] See the tables on the developments in the prices of briquettes in the publications of Beisert and Boker cited on p. 578

[3] "Die Kartelle in der Braunkohlenindustrie," *Z. Braunkohle*, vii., 1908, No. 24.

4. *Brown-Coal Briquette Imports and Exports of the German Empire in the year 1907*

Imported from Austria Hungary		58,884 tons
Exported to —		
Holland		221,185
Switzerland		128,930
France		32,511
Belgium		16,397
Austria-Hungary		13,720
Denmark		5,127
	Total	417,870 tons

5 *Use of Briquettes in Greater Berlin* In the year 1907 Berlin and its suburbs used 1,771,012 tons briquettes equal to 22.2 per cent. of its total fuel requirements By far the greater portion of the briquettes were of Prussian origin the remainder were of Saxon manufacture

II Austria

In 1906 Austria produced a total of 24,167,714 tons of brown coal and only 110,229 tons of brown coal briquettes having a money value of 1,134,357 kr

The brown coals of the majority of Austrian sources more especially those of the principal coal district of N.W. Bohemia,[1] cannot, or can only to a very slight extent, as has already been pointed out on p. 578, be briquetted without the use of a binder and this would render the briquettes too dear Briquetting on the German principle has been in operation for a long time at Konigsberg a. Eger and a few other places possessing deposits of more earthy brown coals, richer in water

According to A Zeese,[2] the Karoline mine of the Prague Credit Bank at Krzemusch has produced briquettes since 1906 A greater binding power and hygroscopic nature is imparted to the coal by a special apparatus (factory secret) attached to the press mould

For a description of the process of making the so-called Kaumazite briquettes from brown coal coke (Kaumazit) at Wesseln, Bohemia, see p. 618

III Other Countries

In other countries, even such as mine brown coals in large quantities, briquetting, if it is carried out at all, is still in its infancy and

[1] For the composition of Bohemian brown coals, see pp. 300-301

[2] "Aufbereitung Brikettierung und Verkokung der bohmischen Braunkohlen," *Z. Braunkohle*, vii., 1908, No. 3, p. 30.

not very extensive—such as, for example, in the United States,[1] particularly in California and Texas. Here, however, as in Austria, the trouble appears to be that the brown coals can only be successfully briquetted by the use of a bond (chiefly asphalt pitch, a cheap residue from the Californian petroleum industry).

Since, however, the globe contains a number of deposits of earthy brown coals capable of briquetting some of which are very extensive and are hardly opened up at all at present, the future of brown-coal briquetting would appear to be very promising

B. APPLICATION OF BROWN-COAL BRIQUETTES.

I GENERAL.

The continual large increase in the application of brown-coal briquettes is due, not so much to the increased use of fuel, as to their special properties and advantages (cf. Section II., p. 285 *et seq.*), and to the efforts of the various works and syndicates to place these advantages over the fuels (pit coals, Bohemian brown coals, wood, etc.) already in the market, in their proper light, to find and cultivate new spheres of use, as well as to arrange and facilitate the maintenance of a regular supply of briquettes at as low a price as possible even to the furthest removed customers

One of the most important factors with regard to domestic briquettes is the support of firms making special briquette ovens or furnaces. In the Rhine district this is effected in a very suitable manner by the Cologne Briquette Selling Agency by means of the following measures -

1. Thorough investigation (heating experiments, etc., carried out scientifically) of the various systems of furnaces, and technical advice as to the removal of all the observed defects
2. Participation in the measures adopted for advertising and popularising those briquette furnaces which have passed the tests
3. Purchase of large quantities of such approved furnaces for supply to users of briquettes at or below the net cost price

The equally important instruction of the customers into the correct treatment of briquettes is also undertaken by the same agency :—

1. By printed circulars giving detailed instructions on the use of domestic briquettes as well as on the semi-stones, cubes, nuts, etc., which are used in the various branches of industry.

[1] *Bi-monthly Bulletin of the American Institute of Mining Engineers*, 1907, No. 17, pp. 789-828.

2. Verbally, by means of lectures emanating from the syndicate and given by engineers, master bakers, etc.

3. By means of free-heating experiments carried out by experts in the plants of prospective customers.

All those technical appliances which effect a cheapening of production, loading, or transport of briquettes are of great influence in increasing the sales.

Attention must first be called to the economy in wages to be effected by general introduction of the method of "chute loading" of domestic briquettes (see p. 527), further to the utilisation of the cheap ship freightage wherever possible (especially on the Rhine), and also to the erection of the necessary loading and unloading appliances such as those at Wesseling on the Rhine and at Rhenanhafen near Mannheim.

In Wesseling-Werft the briquettes are shovelled from the railway waggons into trough-shaped vessels opening at the bottom, which are lifted by the various cranes (each having a capacity of 300 tons in ten hours) for lowering through openings into the ships hold (usually 800 to 900, and occasionally 1500 tons), where the briquettes are dumped with only about 2 per cent. breakages.

At Rhenan, on a large storage ground of 100 acres, acquired by the Briquette Selling Agency in 1905, a large crane provided with "grabs" attends to the unloading from the ship, the storage, and re-loading on the railway waggon. The total costs, including interest and liquidation, amount to 5 marks, the costs of hand working being at least 10 to 12 marks. There is only 5 to 6 per cent. of waste produced, and this is mostly in large pieces which can be sold for industrial purposes in Mannheim at reduced prices. There is, therefore, a total of only about 8 per cent. which can be counted as waste.

By virtue of the diminution in transport costs brought about by ship freightage, the Briquette Selling Agency have been able to considerably increase the sale of brown-coal briquettes in South Germany.

Further, special attention must be called to the considerable reduction of railway freights, the tariff politics of the States concerned, the development of the light railways, etc., and then to the important influence of the measures devised by the briquette producers and selling agencies on the merchanting of briquettes, to the briquette market, the special conditions of delivery (prices), erection of stores, increase of customers, showing at exhibitions (see pp. 528–529), requirements of the users, retail sale according to measure, weight, or number,[1] and so on.

[1] Further information on this point can be gathered from the works of S. Beisert and H. R. Baker alluded to on p. 578.

In the following pages simply the various types and conditions for effective use of domestic briquettes and industrial briquettes, together with the necessary ovens and other appliances, will be dealt with.

C. APPLICATION OF DOMESTIC BRIQUETTES.

I. GENERAL.

According to Oellerich,[1] the requirements necessary in a good room stove may be summed up as follows:

1. As complete a combustion of the fuel as possible.
2. Freedom from smoke.
3. Effective transfer of heat.
4. Simplicity in attendance and cleaning.
5. Effective regulation according to the varying heat requirements.
6. Suitable circulation and renewal of the room atmosphere.
7. Prevention of the exit of gases into the room to be heated.
8. Moderate price and pleasing external appearance.

With regard to the numerous designs of room furnaces for pit coals, heating experts have generally succeeded in satisfying conditions 4 to 8, particularly in the modern type of regulated charge grate. Conditions 1 to 3, however, are only fulfilled more or less incompletely.

The conditions with regard to Bohemian or other similar brown coals are much in the same position, and are probably somewhat more unfavourable, because of the higher content of water. Of the heating value of the fuel burned in room furnaces, only 20 to 30 per cent., at the very best 40 per cent., as against 65 to 80 per cent. in the case of industrial furnaces, is utilised effectively, i.e. given up to the materials of the oven and thence to the atmosphere of the room.

This inefficiency is largely due to the fact that the use of a large excess of air is essential because of the irregular gasification of the coal and the tendency to form clinker. As a result the sufficiently high temperature in the combustion space necessary for complete combustion cannot always be attained, the formation of carbonic acid is rendered more difficult, so that soot is formed in greater or lesser quantities.

Thus a considerable quantity of heat is conveyed to the chimney by the smoke, nitrogen, and excess air, and is rendered useless. Even with good combustion the products pass out of the furnace at far

[1] "Ueber Zimmerofen fur Braunkohlenbriketts," paper read before the Gesellschafterversammlung des Brikettsyndikats zu Coln, August 3, 1903, by Oellerich.

too high a temperature, and thus increase the so-called chimney loss. This diminishes as the difference of temperature between the initial temperature in the combustion space and that of the hot gases at the entrance to the chimney increases.

A certain amount of heat must be conveyed to the chimney in order to maintain the draught at such a pitch that it can overcome the resistance offered to the inflowing air by the fuel, but at the most a temperature of 100° to 150° C. is ample for this purpose.

Higher temperatures of the flue gases therefore indicate a chimney loss which is to be traced to poor transfer of heat as a result of too small a heating surface, or to its ineffective use.

Brown-coal briquettes show up in a much more favourable light than pit and other forms of coal from the point of view of effective utilisation. As pointed out on p. 304 *et seq.* their special properties permit of burning with a smaller excess of air. It is therefore possible in the ordinary room furnace if the grate is chosen narrow enough, or, as very often happens, is omitted altogether, to render a relatively large proportion of the heating value of the briquettes useful and at the same time to obtain an almost smokeless combustion by suitably adjusting the air-supply.

In other respects the utilisation of the fuel in a briquette furnace will become better the more the furnace complies with the above requirements and the more the constructor has taken into account the special characteristics of the briquettes. From this point of view the ease of ignition and the obnoxious gases arising from a deficiency of air provide certain difficulties.

Most of the recent endeavours in briquette furnace technique have therefore been made with the object of producing a good "slow-combustion stove."

Because of these difficulties the arrangement of a charging shaft, which is carried out in various ways, has proved itself more or less unsuitable, because the layer of briquettes is very liable to variation, and, on opening the furnace, smoke is very liable to enter the room. In recent times, however, experiments have been carried out on slow-combustion stoves built on different lines, and have led to various constructions of quite satisfactory types.

II. Burning Briquettes in Cylindrical and Tile Stoves.

Before proceeding with the description of these, simple room stoves, in which all kinds of fuel can be burnt, will be first described,

then some of the better briquette stoves with charging shafts will be considered briefly, for which purpose Oellerich's paper will be discussed.

The cylindrical iron stove is the simplest form of the ordinary room stove. Air enters below the grate, and the hot gases circulate through an iron cylinder, from the upper end of which they pass into a smoke pipe. Such a stove adapts itself better to briquettes than to pit coals, and it is only necessary to limit the air-supply and make the grate narrow enough. Double grates, about 4 to 5 mm. apart, arranged in such a way that the lower one is fixed and the upper one movable, are most suitable, since by this means sieving of the ashes is easily effected. In cylindrical stoves the conditions for development of heat and size of the heating surface are not very good, the regulation is faulty, and the heating efficiency is only 20 to 30 per cent at the outside, even when the heating surface is increased by the provision of long flues. For burning briquettes, however, it possesses the advantage that it is easily attended to in such a way that no smoke can enter the room. In order to obtain better circulation of the atmosphere of the room, the iron stove is often jacketed.

The Tile Oven.—Adopted for a long time, chiefly in the north and east of Germany, the tile stove differs from the cylindrical iron stove chiefly in the material from which it is made, further, by a considerably greater combustion space and in the accomplishment of a much better circulation of the heating gases, etc. Tile ovens originally intended solely for burning briquettes are generally constructed without a grate and without a special ash door.

The differences between iron and earthenware stoves are apparent from the physical properties of these materials. The heat conductivity of iron is thirty-three times greater than that of clay; consequently, an iron stove takes up and transmits the heat absorbed to the room atmosphere much more rapidly than the earthenware stove, whose thicker walls also hinder the transference of heat. However, the Sp. H. of clay (0·1950) is greater than that of iron (cast iron = 0·1298), so that a certain weight of clay heated to a certain temperature can heat up a much greater volume of air than the same weight of iron similarly heated. From this it follows that a steady fire must be maintained in an iron stove, while an earthenware stove can be damped down after once becoming heated.

Burning pit coals in earthenware stoves seldom yields more than 15 to 25 per cent. of the theoretical heating value, while with briquettes the yield can be increased to about 35 per cent. if the stove is attended to properly.

Rules for Burning Briquettes in Tile Stoves.[1]

The following applies to tile stoves and cooking stoves with grates:—After the heap of briquettes (preferably built up irregularly) has been well ignited by means of fire-lighters, pine-wood chips, or the still glowing residue from a previous fire, the upper firing door must be completely closed and air only allowed to enter through the ash pit door. As soon as the whole interior is at a full red heat the air supply is cut off by closing the lower door without poking or loosening the fire.

In stoves without grates and possessing only one door, so long as the briquettes are taking fire, the door is opened about ¼ or closed only to such an extent that the briquettes can burn readily. As soon as they are at a full red heat the door must be completely closed without previous stirring. In both cases the high oxygen content of the briquettes is sufficient to maintain gradual combustion for several hours.

The unfortunate widespread belief that a brown coal briquette can only be applied for placing in the stove after a good red heat has been obtained by some other fuel is quite erroneous. So long as the stove is previously heated in the manner described above, at least the same effect is obtained as with other fuels.

III. Burning Briquettes in Slow Combustion Stoves

Of the older slow combustion stoves with charging chutes intended for brown coal briquettes, and which are not completely satisfactory on account of the facts given above, only the Ilse stove,[2] the Union circulating stove[3] of the Maschinenbauaktiengesellschaft Union, Essen a. Ruhr, the regulated charging stove of the Kongl. Wurtt. Hutten-werks Wasseraltingen[4] in its special application to brown coal briquettes (with a heating efficiency of about 35 to 40 per cent.), the lignite stove[5] of Clemens Lanzen in Unna (heating effect 40 to 50 per cent.), and the stove derived from it, viz. the Amsterdam stove of the Bruinkohlenbrikettenhandel in Amsterdam will be mentioned here. The latter, and a few more recent slow combustion briquette stoves, are described briefly below.

The Amsterdam stove is provided with a charging shaft stretching right down to the grate, so that it can take up a large quantity of briquettes. The hot gases resulting from the combustion of the lowest layer pass upwards through a space surrounding the charging shaft, are reversed below the top plate, and led into a smoke chamber divided into two sections and situated at

[1] From a pamphlet, *Ueber Brikettfeuerung mit Briketts aus deutscher Braunkohle und ihre wirtschaftliche Bedeutung*, published by the Deutsche Städteausstellung, Dresden, 1903.

[2-5] Illustrated and described by Oellerich in *Zimmeröfen für Braunkohlenbriketts*, 1906.

the back of the stove. By means of a damper in the ash pit the gases are deflected up the other section of the smoke box, from which they are led outwards to the chimney. The bottom supply of air admitted below the grate is controlled by a regulating device. During lighting up, which is effected through the fire door, direct draught is provided by cutting out the smoke box by introducing a damper and leading the hot gases to the chimney by the shortest path.

Fig. 239.—Slow-combustion stove for brown coal briquettes (Wilh. Josten, Neuss).

In Wilh. Josten's latest slow-combustion stove (fig. 239), stoking is effected from an external storage box quite independent of the combustion space, and separated from it by a layer of air which effectively prevents ignition of the briquettes before they reach the grate. The storage box consists of a number of pockets inclined downwards, from which the briquettes can be supplied to the furnace in series of 2 to 10 one after the other. It is suspended by means of a chain and pulley.

W. Hilgers[1] has proposed another design of regulator charging stove in which a conveyor with sheet-iron carriers is arranged in a double-sectioned fore chamber, or a box fixed independently of the stove, and operated by a clockwork mechanism in such a way that the outward travelling plates, each loaded with one or more briquettes, discharge their burdens on to a chute and thence to the grate at regular intervals of time.

The speed of the conveyor, and therefore the rate of charging, must be capable of automatic regulation by means of braking arrangement controlled by the room temperature with the aid of a contact thermometer or spiral spring.

In addition, the air supply must be regulated externally. If it is once regulated approximately, subsequent control proceeds automatically, for if too much cold air enters, the room temperature falls rapidly, and results in a corresponding speeding up of the charger, resulting in a correction of the excess air defect by an increase in the amount of fuel to be burned. In any case, the fuel must be burnt to carbonic acid as completely as possible, so as to obtain

[1] *Z. Braunkohle*, 1904, No. 19, pp. 253–256, figs. 95–96.

the maximum heating effect Hilger's proposals appear to be very worthy of consideration, although the driving mechanism and accessories appear to be very complicated, and their construction appears to be rather costly.

Roux System of Slow Combustion Stoves.[1] This stove, designed by Roux, a partner in the firm of Brunelle & Co., Paris, consists of a cast iron, mussel shaped housing, closed at the front by means of a door. The grate has a distance between the bars of only 4 to 5 mm., and is arched to provide uniform draught. By means of a small rosette, the amount of air admitted to the grate, even under the full draught of the chimney, is so small that only a portion of the fuel (briquettes) is completely burnt to carbonic acid; the remaining and smaller portion is incompletely burnt, with the production of hydrocarbons and carbon monoxide.

The hot gases then come into contact with a hollow, cast iron piece lying across the fire, escape from the fireplace, and are led back again to the hot cast iron piece through a bent tube. The cast iron piece is provided with grooves and slots through which small flames are sucked and cause ignition of the still unburned gases; the air necessary for this purpose is admitted direct from the outside by means of a special valve. In this way the gases are completely burned, and are led off to the chimney through the various pipes.

In this case the combustion takes place in stages, thus permitting of quite an exceptional yield of the total heat of the fuel. At the same time the transfer of heat is quite good, since not only the surface of the stove itself but also the tubes act as surfaces for the radiation of heat. Consequently, an extraordinarily high efficiency is attained. Oellerich estimates it at between 70 and 80 per cent. The whole of the waste gases are free from smoke, and escape at a temperature below 100° C.

The stove requires very little attention; a few briquettes only need be laid on two or three times every twenty-four hours. As a separate room stove, it is jacketed in order to promote circulation of the atmosphere.

It can be adapted without alteration to the fireplaces customary in France, England, and Holland simply by omitting the cast iron casing.

D APPLICATION OF INDUSTRIAL BRIQUETTES IN SMALL AND LARGE FIRING PLANTS

I GENERAL

Just as an endeavour is made on the one hand to diminish the net costs and provide a moderate selling price by the production of briquette forms (half-bricks, cubes, nuts, broken briquettes and so on—see p. 285 *et seq.*, and p. 466 *et seq.*) suitable for operations on a large or small scale, so, on the other hand, efforts are continually being made by firing experts to adapt, as far as possible, existing firing plants to the properties of the briquettes and to develop new types of furnaces in which the special advantages of briquette firing can be utilised as completely as possible.

[1] Oellerich, *Ueber Zimmeröfen für Braunkohlenbriketts*, 1905, p. 12

II. Application in Bakeries.

Formerly the heating of baking ovens was carried out almost exclusively, and is still effected extensively, by means of wood. The enormous development of vapour and smoke under such conditions, with the resulting detrimental effects on the surroundings of the bakery, is well known. Heating by means of briquettes—which has been recently introduced and has already achieved success—immediately remedied the defect, and, thanks to the high price of wood, has resulted in considerable fuel economies in spite of the fact that the usual channel baking ovens only utilise the heating power of the briquettes very incompletely.

The new Roux bake oven described by Oellerich[1] has given very favourable results. It is built on the general principles laid down in the above description of the Roux room stove.

Oellerich has made heating experiments in such a baking oven which was not connected to the chimney, and obtained complete absence of smoke and a very low temperature of the waste gases, while the temperature on the baking hearth varied continually between 250° and 350° C. In such an oven 130 kg of material can be completely baked in 19 to 20 mins. with 12 kg. of briquettes. To obtain the same output in an ordinary channel bake oven, 65 kg. of briquettes and a time of 3 hours are required. The Roux system of baking oven marks therefore a remarkable advance.

III. Application in Brick Kilns.[2]

In the German brown-coal districts the seams are often accompanied by clay, which requires a very high temperature in burning during working up to ordinary building bricks. Such temperatures cannot always be attained in ring ovens when using wet crude brown coals, so that the use of Bohemian brown coal or pit coal has been introduced for this purpose and has maintained its position to the present in most brickworks in spite of all progress made in briquetting, principally because of the fact that the various large, medium, and small forms of industrial briquettes tried from time to time have not been suited to brick kilns. Only in recent times has it been found possible to produce the small irregular shapes suitable for this purpose on an industrial scale.

[1] *Loc. cit.*, 1905, p. 15, fig. 13.

[2] C. Loesser, "Ueber die Verwendung von Braunkohlenbriketts für Ringofenstreufeuer," *Z. Braunkohle*, iii., 1904, No. iii., pp. 33-36.

They are illustrated by the broken briquettes (Venator patent, p. 294) in fig. 110, No. 10, of the Akt.-Ges Ramsdorfer Braunkohlenwerke in S.-Altenberg, and brought into commerce by Verkaufsverein der Sächsischen Braunkohlenwerke of Leipzig. Gieche has made prolonged experiments with these briquettes in his circular ovens, and has obtained quite promising results. In a written communication to the above syndicate he says:—"The briquettes burn rapidly and easily. As a result, the fire spreads forward relatively quickly without necessitating increased draught by opening the smoke damper.

This property does not only act favourably on the fuel used, but also on the uniformity of the calcined material.

"In combustion in circular kilns the wider the damper in front of the fire can be opened the longer is the path which the gases have to take on their way to the chimney and the greater they will cool by giving up heat to the kiln thus permitting of a more complete utilisation of the fuel.

"Further, a weak chimney suction which does not tear the fire in the direction of the draught provides a much more uniform distribution of the heat over the area of the kiln and renders possible a much more uniformly burnt material.

"At 3 cm draught the fire passed through more than two chamber lengths (about 10 metres) to the ninth series of heating holes past the fire, five series being at a good red heat.

"Even with so small a draught eight series of heating holes ($8 \times 1{\cdot}06 = 8{\cdot}48$ metres) were burnt in 24 hours, so that operations can comfortably be carried to 10 metres run per day.

"Since, as is generally necessary in circular kilns the fuel could only be supplied in small quantities at 15 minute intervals the formation of slag or fusing of the ash to the material could not be expected at the prevailing temperature—between Seger cone 05 and 06 (*i.e.* 1030 to 1050° C.).

"The briquettes left more ash than the Bohemian brown coals, but the bricks left standing in the ash gave quite a good sound and had a good colour."

Gieche has from these experiments arrived at the conclusion that small broken briquettes such as those of Ramsdorfer are eminently suitable for circular brick kilns.

E. APPLICATION OF BRIQUETTES IN BOILER FIRING.

I. General.

In the choice of fuel for boiler firing, the main determining factor is the cost of the resulting steam, in which the costs of the particular type of fuel chosen and the quantity necessary to produce a certain quantity of steam at a certain pressure naturally play the principal rôle. The proportion taken up by attention and maintenance of the furnace plant must also be taken into account In most cases the attention costs of one and the same plant are approximately the same, regardless of the type of fuel used However, the costs of maintenance, particularly those for grates and boiler repairs, may show considerable differences over prolonged periods of time when using different fuels.

The prevailing fuel costs for a definite quantity of steam are determined by

1 The cost of a kilogram of coal at its place of use, made up of the price at the pit plus the freight charges.

2. The calorific value of the fuel in calories per kilogram.

3. The degree of utilisation of the heating value which can be obtained in the furnace plant in question under practical conditions (kilogram of water at 0 C which can be converted into steam at 100° C.), or the efficiency of the stoking At the brown-coal pit itself and in its immediate surroundings the generally applied stoking with crude brown coals provides the cheapest production of steam in spite of the high content of water and the resulting low calorific value. But at a more remote distance the freight costs attain a certain height, and the stoking of crude coal, which consists of about 50 per cent. water for which freightage has to be paid, becomes very much more expensive than firing with briquettes containing only about 15 per cent. water and obtainable from the same or a neighbouring brown-coal mine. In this case the higher calorific value of the briquettes decides the issue

II. Relation to Bohemian Brown Coals.

Compared with the superior and best Bohemian brown coals whose calorific values are about the same as those of the German brown-coal briquettes (see p. 300 *et seq.*), the difference in price at the mine and briquette factory and the freightage costs are of determinative importance.

As a rule the Bohemian brown coals can be obtained at a lower cost, and may therefore be sent greater distances; or, in other words,

they can carry higher freightage costs than the artificially prepared briquettes.

The difference in selling price at the works is one which varies with the conditions of production in the two cases, the conditions of the markets, and other circumstances. In general, however, it is not very considerable.

In any case brown-coal briquettes—disregarding for a moment their special advantages—will be economically advantageous for steam production at least at all places where they can be obtained cheaper—even if ever so little—than the best Bohemian brown coals. This applies to a large area round the central German briquette factories.

As regards the poorer brands of Bohemian brown coals, the boundary line at which the user can, for a certain definite sum of money, obtain the same number of units of heat from Bohemian brown coals as from German briquettes, is naturally displaced in favour of the latter to a greater or less extent, according to the difference in price of the two varieties. However, this condition is not yet given due consideration by many workers.

III. Relation to Pit Coals

Compared with pit coals of ordinary quality, the limit is approximately reached when the price of the same weight of briquettes amounts to [illegible] that of coal, since the calorific value of brown-coal briquettes is about [illegible] that of pit coal (p. 302).

In very many cases, however, brown-coal briquettes will prove superior to the competitive coals from the point of view of economy in fuel costs, even above the limit set by price conditions, because the calorific power of the briquettes can be utilised better in a uniform steady process of combustion without the complicated appliances and continual close attention which are necessary in the case of pit coals and Bohemian brown coals. Further, there are the advantages of combustion with the formation of the least possible quantity of smoke, almost or complete absence of cinder formation, slight depreciation of the grate and boiler plates, and other advantages dealt with in detail under "Behaviour on Burning" and "Residues of Combustion" on p. 304 *et seq.*

According to the results of numerous exhaustive tests carried out by the Coblenz Boiler Inspection Syndicate and others, a large output can be obtained from the boiler (up to 25 kg. steam per hour from 1 sq. metre of heating surface) with the ordinary horizontal type of grate. The grate surface need not be greater than that required for

pit coals, and, according to the efficiency of the whole plant, an evaporative power of 4·8 to 5·5, or under favourable circumstances up to 6, may be obtained. This is shown in the following evaporative tests communicated by Oellerich :—

EVAPORATIVE TESTS OF RHENISH BROWN-COAL BRIQUETTES MADE BY THE COBLENZ BOILER INSPECTION ASSOCIATION. HORIZONTAL INTERNALLY-FIRED GRATES.

	October 27, 1902.	October 28, 1902.
I. *Conditions of Working*		
Demands made on the boiler	Excessive.	Normal.
Size of grate in sq. metres	3·14	3·14
Ratio of grate to heating surface	1 : 41	1 : 41
Width between the bars in mm	4	4
Length of the grate in metres	2·25	2·25
Inclination of grate	1 : 17	1 : 17
Ratio of section above the fire bridge to the section of the furnace tube	1 : 2	1 : 2
Thickness of fire in mm.	200	200
II. *Notes and Observations during Tests*		
Duration of tests in hours	6·92	8·25
Average content of CO_2 in the waste gases per cent	10·0	10·6
Average temperature of the waste gases in °C	293	249
Average draught in front of the damper in mm water	29	13·6
Average steam super-pressure in atms	7·8	7·2
Number of stokings per hour	...	3·6
III. *Results of the Tests*		
Grate requirements —		
Briquettes used (gross weight) per sq. metre of grate surface per hour in kg	176	144
Work done by heating surface —		
Steam produced per sq. metre of heating surface per hour in kg.	23·2	19
Output :—		
Gross evaporative power of 1 kg briquettes in kg of steam	5·49	5·50
Gross evaporative power calculated to water at 0° C. and steam at 100° C.	5·51	5·53
Efficiency :—		
From 1 kg. briquettes, with a calorific value of 5027 cals., the calories used in the steam formation	3518	3539
Calorific efficiency of the plant	70·0	70·4
Heat balance : —		
Percentage used in steam formation	70·0	70·4
Sensible heat lost in the waste gases (chimney losses) per cent	19·5	15·9
Other losses in unburnt gases, radiation, conduction, etc., per cent.	10·5	13·7
Total	100·0	100·0

Oellerich[1] has obtained still more favourable results in an accurate series of evaporated tests carried out in 1903 on a small French boiler provided with Roux briquette firing. The details are :—Grate surface

[1] *Ueber Zimmeröfen für Braunkohlenbrikets*, Oellerich, *loc. cit.*, pp. 15-16.

0·4 square metres, heating surface 10·1 square metres, ratio of grate to heating surface 1:22·75. In 5 hours 10 minutes 910 litres of water at 19° C. were evaporated with 150-kg. briquettes during which time:—

The boiler pressure was	3·6 atms.
The chimney draught	3 mm
The average temperature of the gases	215° C

Consequently: The gross evaporative power of 1 kg. briquettes was 6·06, or, calculated to water at 0° C. and steam at 100° C., 6·0; 3822 cals. from each kilogram of briquettes were applied usefully, so that the efficiency was 80–81 per cent.

Considering that the French boiler is generally a very poor evaporator, the output of the fuel was an exceptionally good one. This is assisted by the fact that even during the addition of fresh fuel the combustion was completely smokeless. The fact that such good use was made of the boiler with a chimney draught of 3 mm. is also a very important one.

IV. Arrangement and Attention of Briquette Furnaces

On the basis of many experiments and prolonged experience the following advice[1] is given:—

1. The grate surface must be of ample size.

2. The construction of the grate must be so that the surface is an open one even with a relatively small distance between the bars (3 to 5 mm.).

3. The large grate area must be made as accessible as possible by the provision of several doors.

4. The thickness of the layer of briquettes on the grate must be kept at about 15 cm.; fresh briquettes should therefore always be laid on in small quantities at frequent intervals, and should be disturbed as little as possible during the combustion.

5. The grate should be rid of any ashes or clinker about three times during a twelve-hour run, about half an hour after the addition of a charge of briquettes. Before breaking the clinker with a sharp-pointed poker, any unburnt lumps of briquette should be moved to the side as carefully as possible. After removing the clinker a supply of fresh briquettes can be charged immediately. For an hour after cleaning, stirring the fire is not necessary, but after this it is advisable to

[1] *Z. Braunkohle*, ii., 1903, No. 5 p. 62.

gently loosen the thin layer of clinker every half or three-quarters of an hour.

6. Burning of the grate bars may readily occur under certain conditions, and is prevented by arranging that the ash-pit, made of sheet-iron or cement work, is kept full of water The steam produced is exhausted with the air, cools the bars, renders the clinker porous, and in passing through the fire is decomposed into hydrogen, which possesses a very high calorific value [1]

F APPLICATION TO THE PRODUCTION OF PRODUCER GAS.

Both crude brown coals and brown-coal briquettes are suitable for the production of power gas for gas engines The Gasmotorenfabrik Deutz, the Aktiengesellschaft Gebr. Korting, Kortingsdorf, near Hannover, and other concerns have designed special gas producers and suction-gas producers for both kinds of fuels with quite satisfactory results.

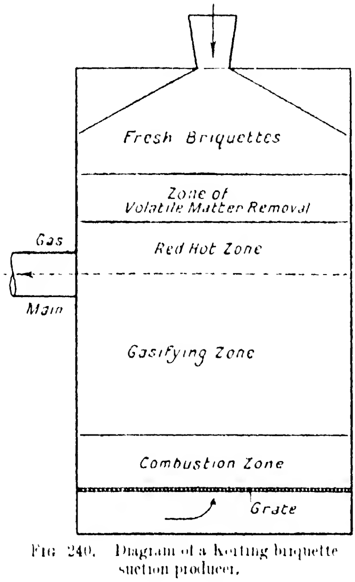


FIG 240. Diagram of a Korting briquette suction producer.

In every case it is essential to obtain a pure gas as free from tar as possible At the beginning the tarry distillation products of the fuels gave rise to considerable difficulties from this point of view, but by special arrangement of the producer the difficulty has been satisfactorily overcome in such a way that the tar is utilised for the production of gas.

Fig 240 shows the scheme of a modern Horting briquette suction-gas producer in vertical section. The outlet pipe for the gas is situated about the middle of the side of the producer body half way between the charging hopper at the top

[1] Above 1000° C the decomposition of water takes place according to the equation —

$$H_2O + C = H_2 + CO,$$

and at lower temperatures.

$$2H_2O + C = 2H_2 + CO_2$$

and the grate below. Fresh briquettes are charged through the open hopper on to the more or less converted briquettes filling the shaft. The main portion of the air enters through the hopper and a smaller proportion enters through the grate at the bottom. Immediately above the grate a combustion zone is formed above which is the real gasification zone, and in the upper part of the producer the briquettes charged are deprived of the volatile tarry constituents by the heat of the gasification zone. The volatile constituents mix with the air introduced above and burn in the hot zone thus becoming completely changed to permanent gases. Consequently a gas is obtained which is technically free from tar and after purification in a scrubber and a sawdust purifier with two grids presents no further difficulties.

The yield from 1 kg. briquettes amounts to about 2·8 cubic metres of gas of the following average composition:

H	11·5 per cent.
CO	21·4 „
CH_4	1·8 „
CO_2	7·4 „
N	57·9 „

and having a calorific value of 1100 to 1200 calories. The consumption of briquettes amounts only to about 0·65 kg. (1½ to 1 lb.) per horse-power hour.

The working of the generator is very simple. For starting up a new plant a small exhauster is generally applied, while in the ordinary course of operations the natural chimney draught is sufficient to keep the producer alight. It should be cleared out about every twelve to fourteen days.

In the so-called double producers,[1] which are similarly arranged and frequently applied—e.g. the briquette suction gas producer of the Gasmotorenfabrik Deutz—a mixture of steam and air enters below the grate.

This also represents, to a certain extent, the practice of Schüchtermann & Kremer... Krudewig G. m. b. H., and the Gasmotorenfabrik Hennef,[2] of which fig. 241 represents an example of the construction.

The fuel is led into the producer a through the closable charging hopper d–e, from which it passes to the grate c through the combustion

[1] *Z. Braunkohle*, vi., 1908, No. 51 (fig. 349). "Die Erzeugung von Kraftgas aus Braunkohlenbriketts," by P. Meyer, Halle a. S.

[2] *Ibid.*, iii., 1905, No. 16.

chamber *b*. On first setting into operation, the mixture of air and steam is introduced below the grate by the pipe *f*, connected to the pipe of the fan by means of the three-way tap *h*, while the gas is removed through the pipe *g*. When the producer is sufficiently blown into action the three-way tap *h* is turned until the pipe *i* communicates with *f*; the mixture of air and steam again enters from above into the annular space *k* surrounding the portion *e* of the charging hopper, passes through the shaft from top to bottom, and the gases are drawn off through the pipe *m* above the grate.

The opening of the pipe *m* is provided with a dividing wall *m'* to

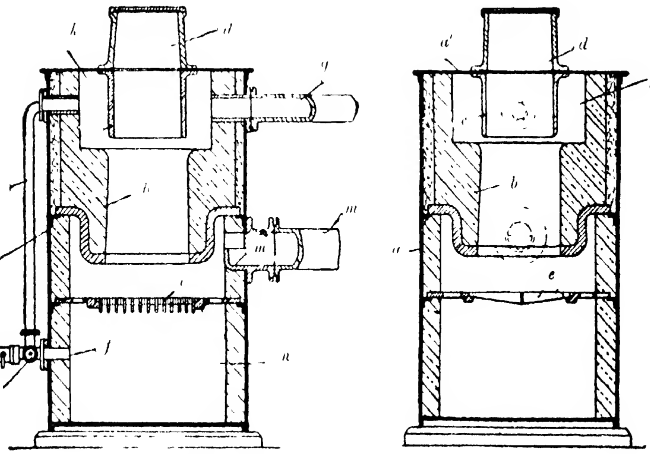


FIG. 211.—Scheben & Krudewig briquette suction-gas producer.

prevent the carrying over of impurities. The construction of the portion *e* in the charging hopper and the introduction of air through the space *k* make it possible to limit the height of the column of fire in the producer and to prevent the entrance of burning fuel into the charging hopper. By this means it is possible to charge fuel over long periods without the risk of fire in the hopper.

Economy of the Briquette Gas Producer.—In the Körting suction producer described above, and also in a producer of the Linden-Hoyerswerda[1] type, the briquette consumption amounts to:—

1. 0·65 kg. per. H.P. hour when taking 100 H.P.

A series of tests reported by Manté gave the following figures for the consumption:—[2]

[1] *Z. Braunkohle*, 1904, iii., No. 45.
[2] *Ibid.*, 1905, iv., No. 20.

2. 0·98 kg. per H.P. hour when taking 50 H.P.
3. 0·668 „ „ „ „ 110 „
4. 0·573 „ „ „ „ 140 „

At a price of 105 marks per double load briquettes, which about corresponds to the Berlin freight costs, the costs per H.P. hour amount to.—

0·682 pf. for 1	1·020 pf. for 2
0·701 „ „ 3	0·602 „ „ 4

Comparison with the cheapest anthracite peas is of special interest. Comparable figures based on a price of 700 marks for at Berlin are:—[1]

For a	50-H.P. producer using	0·36	kg. per H.P. hour	1·08 pf.,
„ „	120 „ „	0·32	„	0·96 „
„	16 „ „	0·55	„	1·65 „
„	25 „ „	0·446	„	1·338 „
and „	60 „ „	0·4	„	1·2 „

which are considerably higher figures almost throughout.

The following figures[2] are published as comparative data regarding the Linden suction producer consuming Bockwitz nut briquettes and anthracite peas:—

	Price of Fuel per Ton for Berlin.	Price per 100,000 cals. Power Gas.
	M	M
Nut briquettes .	13·6	0·326
Anthracite peas .	31	0·433

The production of gas from briquettes therefore is the cheapest by 0·107 marks.

Although the use of brown-coal briquettes appears to be of advantage in places where fuel is costly, it does not appear to be advantageous to operate suction producers with them at briquette factories or brown-coal pits. For this purpose the crude coals and waste, for which there is little or no sale and which always exist in quantity, is generally sufficient.

A brown-coal and briquette works overlooking this fact and

1. *Z. Braunkohle*, 1903, ii., No. 27.
2. *Z. des Vereins Deutscher Ingenieure*, 1904, p. 1272; see also Lewicki, *Wirtschaftlichkeit und Betriebssicherheit moderner Dampfkraftanlagen im Vergleich mit Sauggasgenerator-Gaskraftanlagen*, Berlin, 1904.

equipping its central electric station with two briquette gas producers for preparing gas for two 130-H P. gas engines would have to expend 19·3 pf. for briquettes to produce 100,000 cals., while it would only cost 7 pf for waste coal to produce the same number of cals.

G. APPLICATION OF BRIQUETTES IN SMELTING.

Recently the Cologne Briquette Selling Agency have succeeded in introducing brown-coal briquettes into smelting operations, especially in steel works [1]

[1] *XIV Jahresbericht des Vereins fur die Interessen der rheinischen Braunkohlen-industrie*, 1907

SECTION VIII

PREPARATION OF WET-COMPRESSED BLOCKS.

A GENERAL

THE preparation of wet compressed blocks from earthy moist brown coals is older than the production of kiln dried blocks or briquettes and is derived from the old hand moulding (Saxony) and block forming (Rhineland) (see pp 2 to 4 and fig 1)[1] In Hesse (Wetterau) the preparation of moulded blocks or trampled stones which was customary for a long time but has now been discontinued for some years, formed a sort of introduction (figs 242 to 244)

The crude brown coal supplied was spread out on the ground, and after the removal of the coarse woody particles, mixed with water until it was quite pasty, thoroughly mixed up, kneaded by trampling and carried to the "Tenne," where it was laid down 20 in high, scraped smooth with occasional watering, allowed to dry in the air for several days and then tamped hard with a wooden rammer (fig 242)

Then followed the cutting of rectangular blocks along a wooden plank (figs 242 and 243) and the piling of the blocks into ranges to facilitate air drying

Compared with the crude coal moulding into blocks resulted in a 15 to 25 per cent increase in the calorific value, but the structure was loose and the market limited to a radius of a three to four hours' journey from the works[2]

In order to increase the value of the brown coal and to enlarge its sphere of utility, the block moulding at the Ludwigshoffnung pit at Wolfersheim in the Grand Duchy of Hesse has been replaced by a wet pressing plant provided with waste steam drying (see below)

Since the rise of briquetting however, wet pressing has only increased slowly in scope and importance, chiefly in the province of Saxony, the Thuringian States, and the kingdom of Saxony. In the

[1] For further information see *Die deutsche Braunkohlenindustrie*, 1907, ii, Section 2, 'Die Naszpreszsteinfabrikation,' by Richter (p 6 *et seq*)

[2] "Die Herstellung sogenannter Formklotze auf den Braunkohlengruben der Wetterau," R Hissel, *Z. Braunkohle*, iv, 1906, No. 49, p 689 *et seq*, figs 347 to 354.

Lower Lausitz and the Rhenish district wet pressing was never developed to any considerable extent, and since 1907 practically no wet-compressed blocks have been made.

FIG. 242.—Ancient moulded block preparation from wet brown coals in the Wetterau. Cutting the blocks.

The total production of wet-compressed blocks in the German Empire reached its maximum value of 740,452 tons in 1901, and then

FIG. 243.—Lifting and piling the blocks into series to facilitate air drying.

sank to 583,229 tons in 1906, of which 420,000 tons (=72 per cent.) was produced at sixty-two plants in the Halle district.

The grounds for the diminution in the wet-pressing industry lie in the properties of the stones themselves (fig. 245). They have little chance with the superior briquettes because of their low strength and

consequent difficulty of transport and their low calorific value. To these defects must be added the difficulties in manufacture. In the methods which found almost universal application formerly, extended areas and costly drying sheds were required for drying the freshly

FIG. 244.—Series of stacks of moulded blocks.

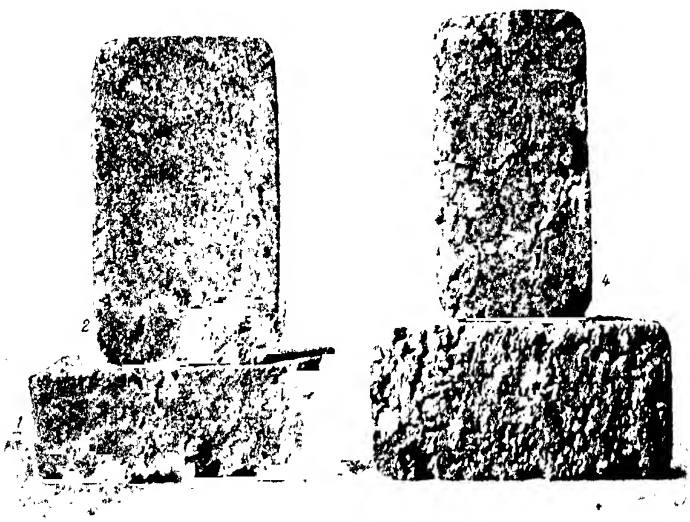


FIG. 245.—Various wet-compressed brown coal blocks.

pressed blocks. Further, the work was confined to the summer months, since even slight night-frost gave rise to considerable damage.

Possibly the Speise method, to be described below, is destined to lead the wet-pressing method into new paths and to assist it to a new and continued prosperity.

B. METHODS OF WET PRESSING.

1. The general method of preparing blocks by means of the *Hertel-Schmelz Wet Press* must first be dealt with. Figs. 246 and 247 illustrate the wet-pressing plant installed for the Zechau-Kriebitzscher Kohlenwerke Gluckauf, at Zechau, near Rositz (Altenburg), by the Nienburger Eisengieszerei und Maschinenfabrik of Nienburg a. S. The press is also illustrated in detail by figs. 248–253.

The wet press is made up of a pulverising and mixing appliance, the press itself, and the arrangement for cutting up the exuded rope of coal.

Pulverising and Mixing Appliance.—In order to obtain good wet-pressed blocks it is essential that the crude coal should be crushed as fine as possible and uniformly moistened with the admixed water.

Generally speaking, the coal passes from a storage hopper, provided below with a toothed roll crusher (similar to fig. 123, p. 330), to the pit of an elevator (fig. 246), which lifts and discharges it on to a pair of coarse rolls 40 to 60 mm. long by 52 to 70 cm. diameter. The rolls are smooth, have a case-hardened exterior, and are 10 to 15 mm. apart (fig. 124, p. 332). They discharge the coal into a Groke mixing and mashing apparatus, which is placed at the side of (as in fig. 247) or immediately below the rolls. The mixer shown on a large scale in fig. 248 consists of an iron trough in which a central shaft rotates. Inclined knives or propeller-shaped wings are attached both to the walls of the trough and the shaft. During operation the coal is by this means chopped up, kneaded, mixed, and carried forward. At the same time it is steadily sprinkled with water from an upper horizontal pipe provided with numerous holes, the flow being carefully watched and regulated by an attendant.

Friable coals require a trough length of 2·5 metres and slight inclination of the knives to effect thorough admixture, while hard coals require a length of 3 to 4 metres and more inclined knives.

The mashing apparatus delivers the coal on to a pair of fine crushing rolls (fig. 246) 3 to 5 mm. apart. By this means crushing and mixing are carried out effectively, after which the coal is delivered to the rear of the rope press.

Th. Groke's wet pressing appliance is provided with an edge runner mill (figs. 19 and 20, pp. 66, 67) instead of the roll crushers and mixing appliance. Foreign materials, such as wood chips, etc., are retained, and the resulting products are considerably better than those of the ordinary methods.

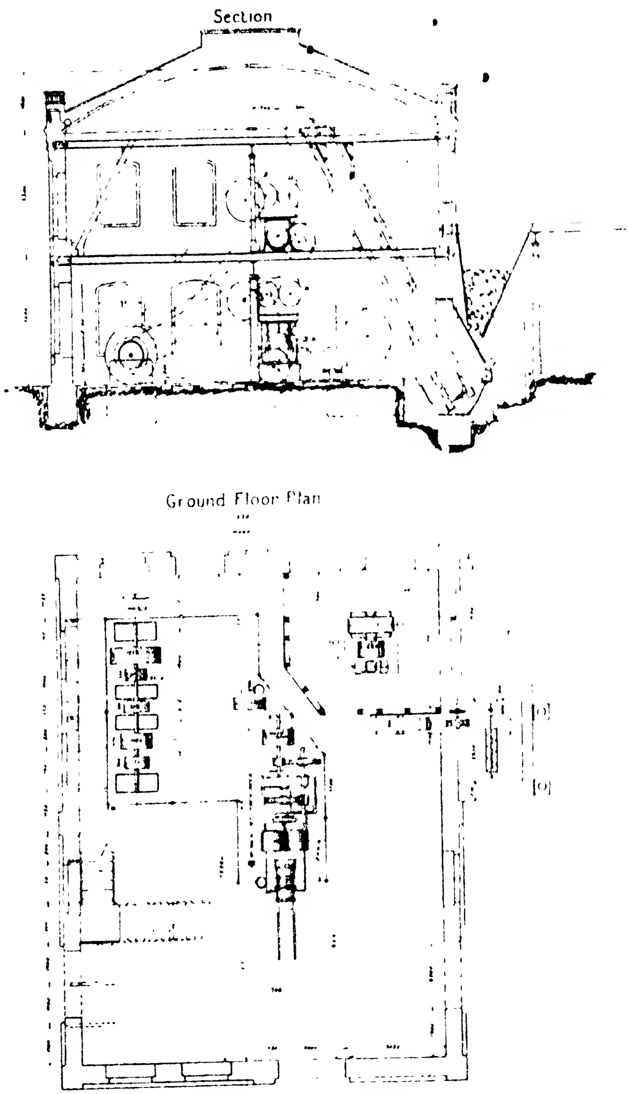


FIG. 246.—Brown coal wet-pressing plant of the Zechau-Kriebitzscher Kohlenwerke Glückauf, built by the Nienburger Eisengiesserei und Maschinenfabrik

The press (fig. 249) is very similar to the ordinary rope press for bricks, and consists of a horizontal cast-iron, partly cylindrical and partly conical, casing, through which passes a strong hollow shaft usually fitted with four propeller-shaped knives. These thoroughly mix the mass of coal and drive it forward through the square mouthpiece as a coherent rope on to the carriage of the cutting appliance. The press is about 1·6 metres long, with an internal diameter at the front and the back of 0·47 to 0·6 metre and 0·7 to 0·75 metre respectively. Two side openings, closed with slides, are generally provided in the front portion in order that stoppages may be dealt with.

Figs. 250 and 251 show this forepart in another and more conical design on a larger scale. It is provided with a mouthpiece (omitted

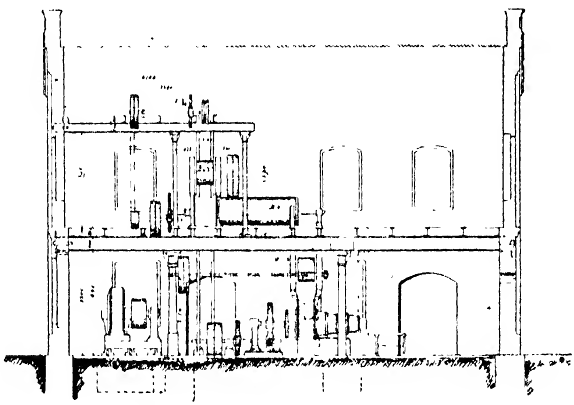


FIG. 247.—Longitudinal section of wet-press plant, fig. 246.

in fig. 249), bolted on at the top. The mouthpiece is made of copper, has a square section narrowing towards the front, and is surrounded by a hollow space through which steam (usually waste steam from the engine) can be circulated. This prevents adherence of the coal to the walls of the mouthpiece and ensures a smooth, even surface for the rope.

The Cutting Appliance (fig. 252).—The coal rope passes on to the platform of a waggon carried on a strong under frame, and is cut across by means of three steel wires (preferably piano wires) stretched in a framework at distances apart equal to the breadth of a block. A workman, standing close to the waggon, clamps the rope between two jaws by means of a lever arrangement operated with the left hand, and either pushes the bar holding the wires forward or draws it back with

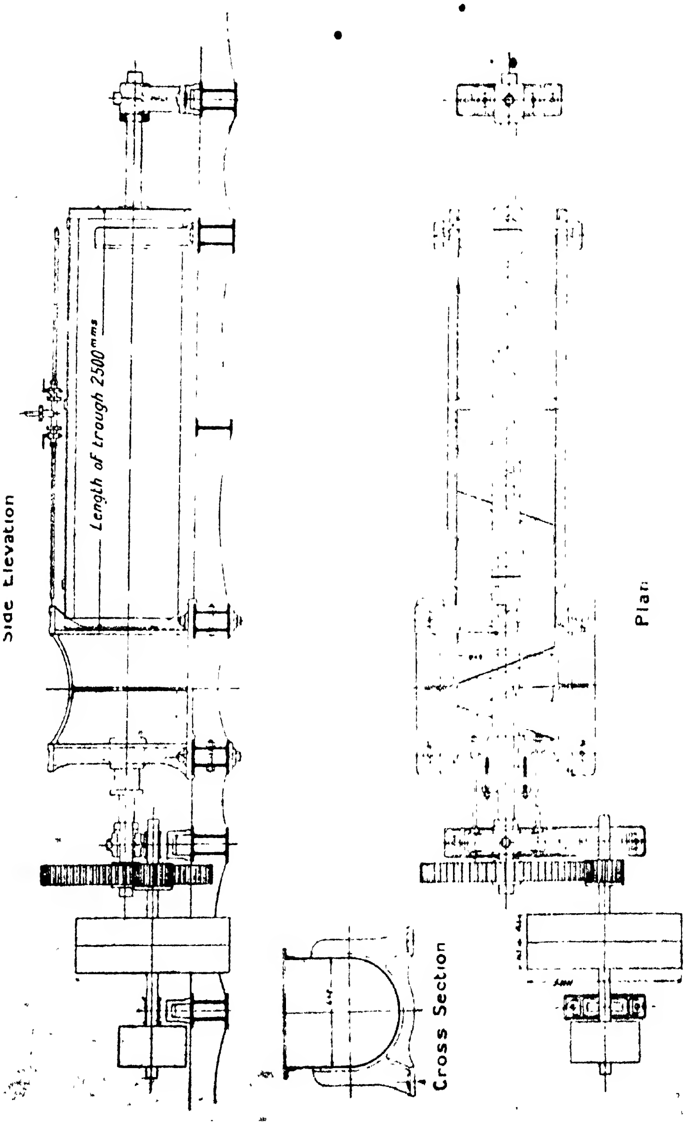


FIG. 246.—Groke mashing apparatus for brown coal and water.

Fig. 249.—Nienburg brown-coal wet-pressing appliance

his right hand and cuts off three blocks during which period the forward movement of the rope has been taken up by the carriage

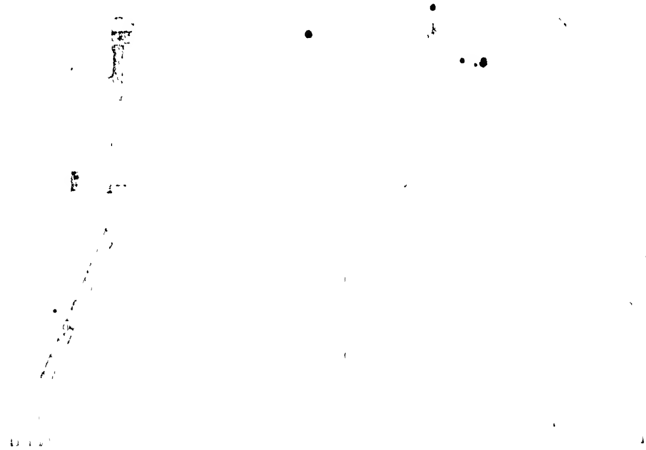


FIG. 250.—Front part of [illegible] mouthpiece.

The clamp is then released when a counter weight draws the waggon into its original position.

The jaws of the clamp, the bottom of the carriage, and the plate in

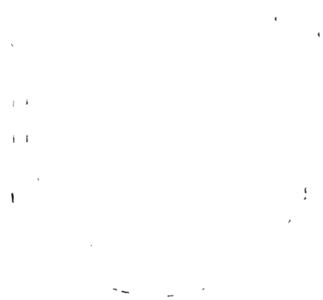


FIG. 251.—Front view of the front part of the press.

front are hollow and heated with steam in order to prevent adherence of the material. Fig. 252 shows the inlet and outlet pipes.

The output of a Nienburg wet press amounts to about 6500 blocks per hour, or 76,000 blocks in a twelve-hour shift, while the power necessary for a complete plant (as in figs. 246–247) amounts to 80 to 90 H.P.

The wet press of Hoddick and Röthe, Weissenfels (fig. 253), differs from the previously described Nienburger appliance principally in the absence of a kneading trough and by the arrangement of coarse and fine roll-crushers immediately below one another, which provides a considerable economy in space and cost of installation. However, hard and irregular coals cannot be dealt with successfully by this machine.

Similar presses are constructed by the Zeitzer Eisengieszerei und Maschinenbau-Aktiengesellschaft, Rohrig & Konig, engineers, Magdeburg, Heymer & Pilz, Meuselwitzer Maschinenfabrik und Eisengieszerei, Meuselwitz (Altenburg), and other firms.

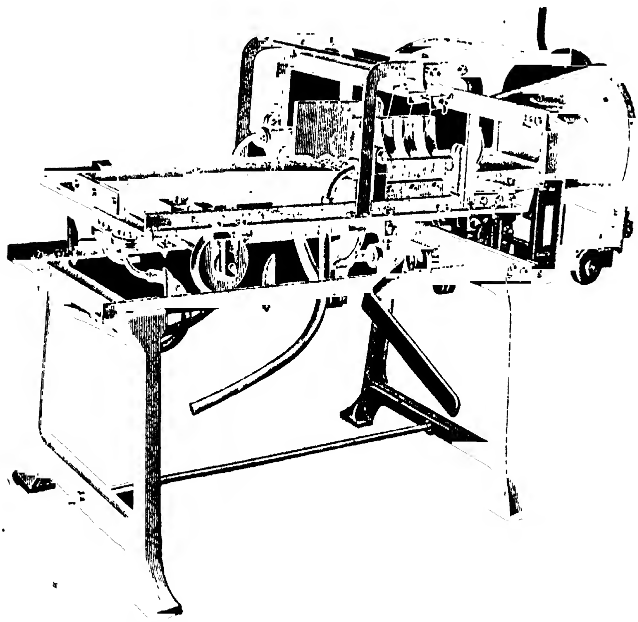


FIG. 252.—Nienburger cutting appliance for wet-pressed stones.

H. Graupner and A. Eisner's automatic cutting apparatus[1] (*D.R.P.*, No. 44518), constructed by the Maschinenfabrik A. Eisner of Lugan i. S., performs the very laborious task of cutting by means of a horizontal steam-engine, which moves a cutting bar across which four wires are stretched. However, it utilises up to thirty wires per shift (*i.e.* five to six times as many as are used in hand cutting), principally as a result of meeting hard particles. It is necessary, therefore, to carry out a careful dressing and purification of the coal.

The drying of the finished wet-pressed blocks is carried out in the atmosphere almost universally. The stones are generally placed on short boards for conveyance in frame waggons to the drying sheds

[1] *Die deutsche Braunkohlenindustrie*, 1907, ii. p. 12.

(fig. 254), arranged on a lattice work at short distances apart, and subjected to the action of the circulating air for two to four weeks, according to the temperature, moisture, and prevailing winds.

The capacity of a drying shed 4·25 metres in height and of 9·34 metres effective breadth, amounts to 3300 blocks per metre of length.

During air-drying the moisture in the blocks decreases to about 25 to 28 per cent. and their cubical contents diminish by about one-fifth, *e.g.* from 210 × 110 × 62 mm. in the case of the wet block to about 185 × 97 × 55 mm. when dry.

The cost of installation of a Nienburg wet-press plant amounts to

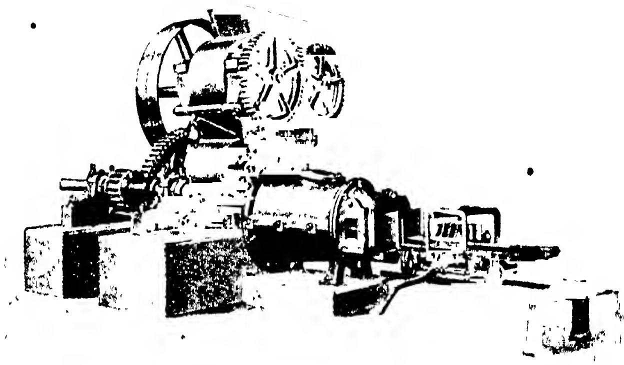


Fig. 253. Hoddick and Rothe's wet press.

about 15,000 marks, exclusive of power plant, transport trucks for blocks, rails, and buildings.

The cost of production of 1000 blocks = 845 kg. in a two-press plant in the Merseburg district, working on the usual lines, amounts to :—

Liquidation of the installation costs .	1·3 marks
24 hl. crude coal at 15 pf. .	3·6 ,,
Wages for pressing, drying, and loading . .	1·6 ,,
Engines, power and oil . . .	0·5 ,,
Administration .	0·5 ,,
Total . .	7·5 marks,

or 8·9 marks per ton. Consequently, briquetting is cheaper than wet pressing.

For the above work a press requires eighteen to twenty attendants, while the two presses are driven by electric motors of 140 H.P.

Artificial Drying of the Wet-Compressed Blocks.—In order to effect more rapid drying, and also to utilise the cold season, when the plant usually stands idle because of dangers of frost, artificial drying by means of waste steam or waste heat has several times been introduced here and there, but has always been given up again.

Recently, however, the Hessian brown-coal mine "Ludwigshoffnung" at Wolfersheim, described on p. 603, has been equipped with a large wet-pressing plant using waste heat on the principle patented by C. Keller of Langenbeck, which, after overcoming many difficulties, appears to be quite satisfactory.[1]

The wet-compressed blocks are kept in closed chambers (24 to 40, each of 30 metres length) heated by waste heat. In order to obtain the maximum uniformity in drying, the series of blocks are arranged close at the bottom near to the source of heat and diverging towards the top.

2. *The Speise Method of Wet Pressing.*[2]—This method, devised by E. Speise of Halle a. S., has been borrowed from the ceramic industry, and is carried out in drop presses on the lines of the Dorsten brick press.

The stamp falls three times on the coal conveyed to the mould by means of a worm conveyor and mixer. Dry coals, containing 20 to 30 per cent. water, are most suitable, but much wetter coals, containing 42 to 52 per cent. water, can be compressed. For coals of over 55 per cent. water the die must be steam-heated to prevent adherence. A smooth pair of rolls, placed 10 to 20 mm. apart, is required to first crush the coarse particles. With the aid of ventilation channels in the moulds and dies, strong pressed blocks, intermediate between ordinary wet-pressed blocks and briquettes, are obtained. According to the report of the inventor, the freshly pressed blocks can be transported direct, or they may be piled about two metres high in covered storage sheds in order that they may dry slowly without the danger of forming cracks. Rapid drying in the sun or in the ordinary drying sheds is not recommended. With the usual size of mould, 200 x 100 x 50 mm., the fresh blocks weigh 1250 to 1300 grm., and 1030 grm. when dry.

The Speise-pressed blocks appear to be considerably more difficult to dry than the ordinary wet-compressed blocks, probably because the latter are made without the addition of water and are porous. Careful comparative experiments on the process of drying have not been carried out, so that no drying curves are available.

In the fire the blocks soon attain a red heat, and stand up well without crumbling. They are relatively unaffected by frost, and can be compressed equally well between -7 and 10° C.

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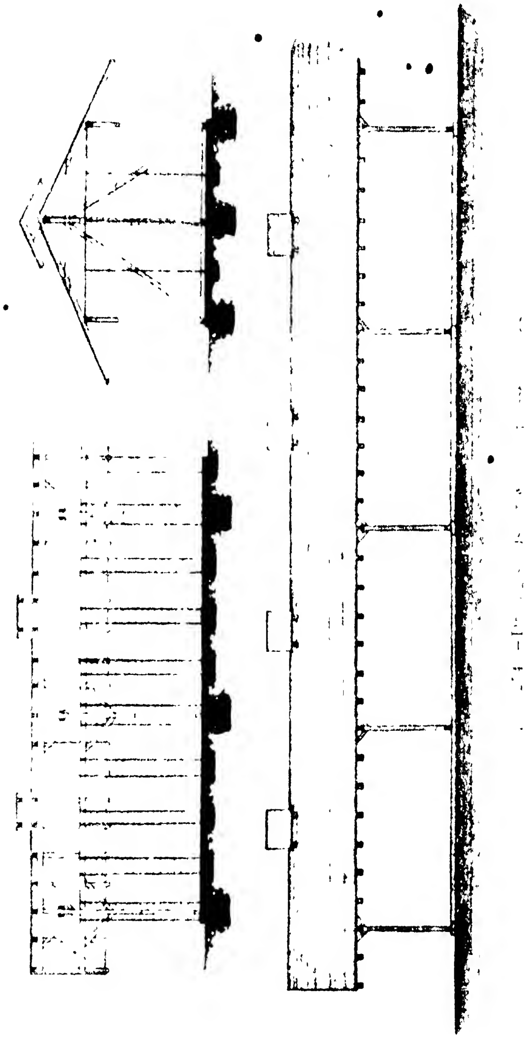
[1] Klein, "Die Naszpreszstein-Trockenanlage auf Grube Ludwigshoffnung bei Wolfersheim," *Z. Braunkohle*, iii., 1905, No. 40, figs. 283-288.

[2] W. Randhahn, "Das Speisersche Verfahren für grubenfeuchte Braunkohle," *Z. Braunkohle*, vii., 1909, No. 41.

Briefly, the Speise method presents the following advantages as compared with the old wet-compression methods—Simpler plant.



absence of drying sheds, dry and improved blocks, longer yearly period of working lower installation and working costs.

The ultimate value of this can only be determined after the method has been applied on a large scale, but the experimental results up to date have, in any case, been highly satisfactory.

APPENDIX.

Preparation of Briquettes from mixtures of Pit Coal, Brown Coals, and Small Coke (Mixed Briquettes), from Peat, Wood Waste, and other Organic or Inorganic Non-Metallic Substances.

I. Preparation of Briquettes from Mixtures of Pit Coals, Brown Coals, and Small Coke (Mixed Briquettes).

F. Utsch of Cologne[1] prepares mixed briquettes of 0·5 to 5 kg. from suitable intimate mixtures of 10 to 90 per cent. pit coal (preferably hard coal) and 90 to 10 per cent. ordinary earthy, undried brown coal, without the addition of any other binding material. Compared with the pit-coal briquettes prepared with pitch, they possess the advantages of cheaper production and of burning much more freely.

At a later date this has been repeated by others (H. Trosken, Dresden, the Kgl. Sachs Steinkohlenwerke, Zauckerode, and others) on similar mixtures with the addition of brown coals, which cannot be briquetted alone, or small coke. Experimentally, more or less superior mixed briquettes have been produced, but as far as is known in no case has a development on a manufacturing scale been attained. Since the various raw materials of such mixtures are seldom or never obtained at one and the same place, one or more of them must be imported, and the process is always burdened with costs of freightage. This makes the question of profit a doubtful one, especially as mixed briquettes, even when dried brown coal is used as the bond, can never attain the calorific value and the selling price of good pitch briquettes.

The modern method of briquetting anthracite and small coke at Point Breeze, Pennsylvania, is dealt with on p. 212 *et seq.*

II. Briquetting of Coke Waste.

The considerable quantities of sieved waste coke, only ignited with great difficulty, which are obtained at coking plants, gas works, storage places, etc., have not, up to the present, been very generally turned to account. Briquetting with pitch as bond has generally proved itself to be either too dear or unsuitable. However, suitable methods have been introduced recently, *e.g.* the production of "desulphurite slow-combustion briquettes" by the method protected by the Bros. Höpfner of Bleckendorf in the Magdeburg district. By this method all kinds of coal, coke, peat, briquette waste, lignite, slimes from coal and anthracite washeries, etc., can be pressed to briquettes in the shape

[1] *Z. Glückauf*, Essen, 1894, p. 1801.

of small cubes or blocks weighing several kilograms, which will burn without smoke, soot, or smell, give off no sulphur compounds, and form no clinker. The cheap binding material used is kept secret, but it can be taken that its chief constituent, resulting in the above properties, is lime (calcium hydrate, lime water, milk of lime, or the like). The briquettes only attain the necessary strength after drying, probably by means of waste heat

With regard to the profits of the method of desulphurisation in its application to coke, Gebr. Hopfner give the following example in a printed advertisement :—

At a coking plant, 150,000 kg of desulphurised slow combustion briquettes have been prepared daily from the waste coke The equipment consists of three plants of the largest type, each for an output of 50,000 kg per day- and night-shifts.

In a day- and night shift, 750,000 cubical briquettes, each 200 grm. in weight, or a total of 150,000 kg., are completed Each apparatus produces 250,000 briquettes = 14,400 per hour and 240 per minute, so that the quantity falling to each shift of eight and a half hours is —

Material :—142,500 kg coke at 1 mark per 100 kg		142·50	marks.
7,500 „ bond „ 15 „ „ „ „		112·50	„
150,000 kg. material free at place of use		255	marks.
Wages (each apparatus per two shifts) :—			
2 men for crushing	6·0 marks		
2 „ „ moulding machines	6 „		
2 boys „ „ „	3 „		
4 men for the channel	12 „		
4 boys „	6 „		
	33 marks		
For the three installations	99 marks		
2 men for bond	6 „		
2 foremen	10 „		
		115	„
Steam plant and drying :			
150 H.P. for 20 hours at 4 pf per H.P. hour	120 marks		
Drying 9000 kg briquettes at 1 mark per 100 kg.	90 „		
		210	„
	Total	580	marks.

Liquidation of the costs of installation (250,000 marks) :—

2 per cent. on buildings 25,000 marks =	500 marks.		
10 „ „ on machinery 200,000 „ =	20,000 „		
10 „ „ on power plant 25,000 „ =	2,500 „		
for 300 days	23,000 marks,		
or per day		76·7	marks.

Interest :—

5 per cent. on 250,000 marks = 12,500 marks per annum,

or per day	.	42	marks.

Rates for licence :—

At 10 marks for 10,000 kg. finished D.D. briquettes	.	150	,,
Total	.	848·7	marks.

Consequently 10,000 kg cost 56.58 marks, the selling price being 108 marks, leaving a profit of about 123 marks.

III. Briquetting of Waste Brown Coal Coke (Kaumazite[1])

For about ten years the Wesselner Koks- und Kaumazitwerke, Aussig, have produced, by degasifying brown coal in chamber ovens, a coke under the name of Kaumazite

The red-hot coke drawn from the bottom of the chambers every three hours is either quenched with water or allowed to cool in pipes, after which it is sorted by sieving into cobbles, of 12 to 24 mm for suction-gas plants, of 4 to 12 mm for boiler firing, while the smalls below 4 mm. are either used in briquetting or in brick kilns.

Using an addition of 7 per cent of the tar obtained in the coking, the Wesselner Co prepare Kaumazite briquettes, which are sold for domestic and industrial purposes, and are in considerable demand because of their special properties, particularly their high calorific values (about 1745 cals).

The brown coal distilled in the tar distilleries of Central Germany gives rise to a porous granular coke, which could be briquetted under the conditions laid down on pp 280–281, but finds a good profitable market without further working up.

IV. Briquetting of Peat and Similar Materials

The endeavours to utilise the deposits of peat found in extensive moors to a better extent than by the ancient method of cutting and drying peat bricks have, from time to time, led to many experiments even on a technical scale They have usually failed, however, because of the great natural difficulties. In its natural state peat contains 75 to 90 per cent water, which must be reduced to about 15 or 20 per cent. Since the peat substance holds water very tenaciously, this is a very difficult matter, for even under the greatest pressure the water can only be diminished from 85 to 65 per cent.

Generally speaking, it is too costly to remove the rest of the water by heating, so that peat briquetting can only come into competition with coal in countries which have little or none of the latter commodity, *e g.* in Scandinavia, particularly in Sweden, where the industry thrives at various places.

So far as is known, there are only a few peat-briquette factories in Germany (Ostrach, Wurttemberg, Langenberg near Stettin, Schwenzelmoor Ostpreussischen

[1] Baum, "Beitrage zur Krafterzeugung und Kraftverwertung auf Bergwerken," *Z. Gluckauf*, Essen, 1906, No. 31, pp. 1014-1015. A. Zeese, "Aufbereitung, Brikettierung und Verkokung der bohmischen Braunkohlen," *Z. Braunkohle*, vii., 1908, No. 3, pp. 39-40.

Pentanwerke). In Russia there is a factory in Irinowka, and one at Helenaveen in Holland.

Recently peat briquettes have been produced in the State of Florida, U.S.A.,[1] by means of Moore presses made by the Wyman Elevator and Machine Works, South Boston, Mass. They are applied in gas producers, for locomotive and boiler firing, and for domestic uses.

Larson has recently published a large technical and economic study of peat briquetting, with particular reference to the methods carried on in Sweden. Several plants are described in detail, and the essential characteristics of the peat moor and other conditions essential to profitable working are intimately dealt with.

The mechanical appliances and machines [illegible] for drying and pressing peat are very similar to those used in the German brown coal [illegible] factories, and the reputable machine builders connected with [illegible] Zeitzer Eisengiesserei und Maschinenbau Aktiengesellschaft in Zeitz, the Maschinenfabrik Buckau in Magdeburg-Buckau, the Maschinenfabrik Rehling & H[illegible], Magdeburg [illegible] send out estimates and deliver appliances and machinery for peat briquetting.

Some accounts of peat drying and pressing in Pomerania and East Prussia, and the Ekenberg method of producing peat coal, are given below.

G. Peters' method of peat briquetting has been carried on at [illegible]enberg, near Stettin, since [illegible]. The peat is cut from a green-land moor 3 to 8 metres in thickness by means of a Brosowski cutting machine, and dried first in the air (recently artificial heat has been used) until it contains about 50 per cent. H_2O. Drying is finished in a Buckau tubular oven, after which, pressing is resorted to in a Buckau rope press of the ordinary type.

According to older accounts, the total cost of cutting and briquetting peat were so high that it was only possible to work at an appreciable profit when the selling price was at least 100 marks per D.W. [illegible] for large quantities and 130 marks for small lots. Since, however, still higher prices could often be obtained, in spite of the competition of English coal, the briquetting [illegible] satisfactory return.

The Ostpreussischen Pentanwerke, Schwenzeimoor, near [illegible], remove most of the water from peat by an electro-osmotic method, produce briquette fragments by a special method, and domestic briquettes in rope presses.

Fig. 255 (1) shows a cross section of, and (2) a complete briquette of such origin; it possesses great strength and a faultless shape and surface.

Treatment of Peat by Dr. M. Ekenberg's Method.—Ekenberg aimed at saving the considerable expense bound up in air drying, by pushing the wet peat into tubes and attaining a simple dehydration by heating under great pressure (*D.R.P.*, Class 10b, No. 169,117, December 31st, 1902). With various modifications this method has been applied profitably in the way of supplying a material suitable for briquetting by ordinary processes.

The International Carbonising Co., Ltd., 37 Queen Victoria Street, London, had, in the spring of 1909, built two large plants on the Ekenberg system—one in Ireland and the other in Germany.

[1] *Bi-monthly Bulletin of the American Inst. of Mining Engrs.*, 1907, No. 17, pp. 789–828, and *Z. Braunkohle*, vi., 1907, No. 39, p. 672.

[2] *Teknisk Tidskrift*, Stockholm, 1907, No. 22, p. 1026 *et seq.*

Production of Peat Coal.—By peat coal, the Deutsche Torfkohlen-Gesellschaft m. C. H., Berlin, understand a briquettable product obtained, as described below, by the Schöning-Fritzschen method, which has been thoroughly tested and taken up by them.

Air-dried peat is broken up in a disintegrator and slightly heated in a retort until the whole of the volatile gases are distilled off. The gases are purified, led to a gasometer

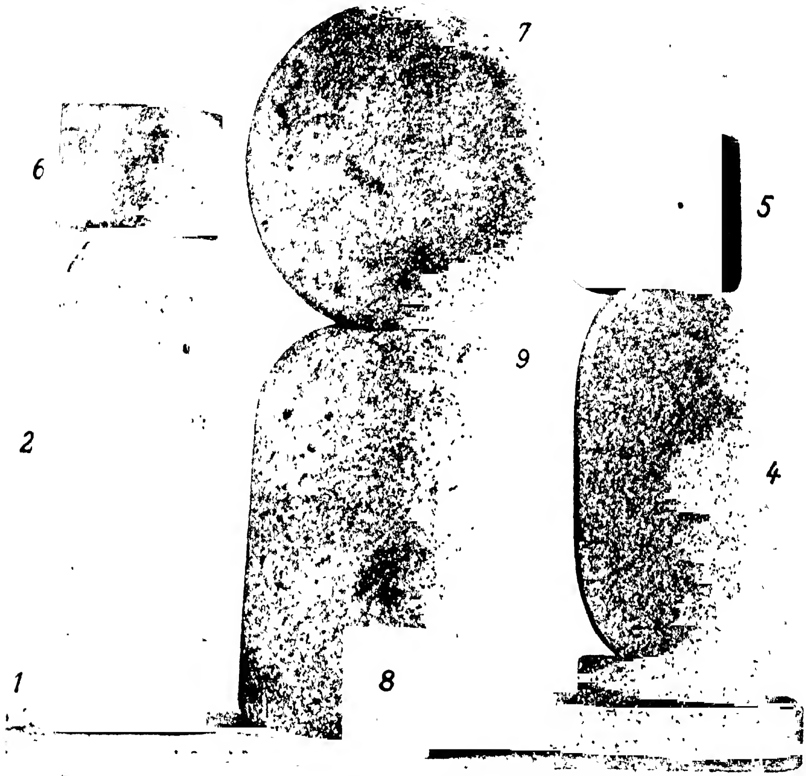


FIG. 255.—Briquettes of peat (1 and 2), wood, sawdust (3 and 4), combustible earth (5), sugar (6), table salt (7 and 8), and cattle salt (9). From the briquette collection of the Hgl. Borgakademie, Berlin.

and used for heating purposes; while the heavy tarry gases are left in the peat, which is then compressed in closed spaces for twelve seconds, during which time it is further heated, resulting in the production of strong transportable blocks of considerable heating power. (According to a 1903 prospectus.)

v. Morsey Picard and v. Verschuer Method.[1]—Peat coal is also the name given to a product obtained from moorland masses without the application of heat and pressure. It has many points of similarity with the very dry granular bricks made of Central German brown coals.

[1] Botticher, *Z. Braunkohle*, vii., 1908, No. 21.

The cut masses of peat are first pulverised in a mixing and crushing machine, and then led by means of a worm conveyor to the so-called electric mouthpiece, a rectangular chest 2½ metres in length, whose two broad sides form the electrodes. While the peat is passing through the chest, an alternating current is passed through the mass continually, bringing about electrolysis of the material, which opens up the turf fibres. It appears that the contained oils and resins are set free, on which depends the whole success of the method of manufacture. The decomposed mass is now brought into a Dolberg peat machine and formed into two endless ropes, each about 8 × 8 cms. in section, which pass on to a cutting machine and are divided into cubes of 8 cm. edge. These are laid on boards and subjected to a preliminary drying in chambers provided with a current of air. After six to eight days the stones are thrown irregularly into drying towers, where the drying is completed by means of pipes heated with waste steam and a current of air produced by a fan. In thirty-six to forty-eight hours the tower can be emptied at the bottom, like a blast furnace, without interrupting the working, fresh blocks being afterwards charged in at the top. The "peat coal" is then finished. It contains 25 to 30 per cent. water, possesses great hardness and strength (giving little or no waste), and can be stored for weeks or months in the open, during both cold and warm weather, without undergoing any appreciable alteration. It is important that only peat from moors of high altitude, such as generally occur in North Hannover, Oldenburg, Mecklenburg, East Prussia, etc., is suitable for the production of "peat coal."

The patentees have been testing their method in a large experimental plant since 1907, and find that the costs of production never amount to more than 5 marks per ton.

Nothing can be said here of the other methods of turning peat to account (by degasification and coking). Prominent experts consider the utilisation in gas producers for the manufacture of power gas, and the resulting cheap production of large quantities of electrical energy, to be the most economical method of dealing with peat.[1]

V. Briquetting of Sawdust and other Waste Wood

These materials can generally be briquetted fairly readily without a binding material, for which purpose the sticky resinous constituents of the wood are used.

In the method devised by Gans & Co., Eisengieszerei und Maschinenfabrik, Budapesth, for the preparation of sawdust briquettes, the fresh sawdust, which usually contains 35 per cent. moisture, is passed through a worm conveyor with a heated bottom, when the water content is reduced to 12 per cent. and the resinous constituents liquefied. The material is then passed to the heated drier and then to a briquette press.

The briquette press used is of the Arnold type (*D.R.P.*, No. 56,750), which is a crank-lever press making 22 strokes per minute and producing about 3600 kg. in ten working hours. The power required for such a press and the attendant driers amounts to about 16 H.P. Sawdust briquettes can also be prepared in a brown-coal rope briquette press. In fig. 255, (3) represents a fractured and (4) a complete specimen of such briquettes. Their strength is

[1] Frank, "Ueber Gewinnung und Verwendung von Torf zu Heizzwerken und zur direkten Krafterzeugung," *Z. f. angewandte Chemie*, 1907, p. 1592 *et seq.*

usually very small and they soon break up in the fire. Sawdust briquetting has not yet attained much importance, although other firms also sell plants and presses for the purpose.

Better pressed blocks called "wood briquettes" can be prepared from the waste from certain types of wood.

The chemical works of Carl Feuerlein in Feuerbach-Stuttgart work up strong briquettes in an ordinary rope press from the extracted and dried woods, usually of foreign origin. These briquettes are very much in demand in the Stuggart district for use as domestic fuels. The woods principally used are quebracho wood from the Argentine, logwood and fustic wood from Central America, and some chestnut wood and oak. Wood briquettes come into commerce in sections of rope which can easily be broken off at the dividing surfaces before use. Long, thin briquettes made from pine-needles are specially valued for igniting purposes.

VI. Briquetting of other Organic or Inorganic Non-Metallic Materials.

The number of such materials which can be briquetted with or without binding material is very large, but up to the present only a few of them have been subjected to treatment on a technical scale. Of other fuel briquettes, mention must be made of such as are made from various waste products, bituminous shales, petroleum which has been solidified with or without the addition of sulphuric acid and lime, and other mineral oils alone or mixed with sawdust or house refuse, etc. Fig. 255 (5) shows a briquette of combustible earth, and (6) a sugar briquette, both prepared experimentally in a Continual press, while (7) to (9) show various types of salt briquettes. The disc-shaped block (7) was produced from moist, ground salt under high pressure in a hydraulic press by the Weisz method as worked by Nay & Strausz of Budapesth. Salt in this or other similar strong and regular shape is very much prized in Galicia, Hungary, and the Balkan States. The daily requirement is removed by scraping.

In Austria, where the salt monopoly exists, the briquetting of salt[1] was introduced about ten years ago in order to supplant the sticks or measures of salt which are still made at many salt works. At Ebensee, 50,000 briquettes, mostly cubes of 1 kg. weight, have been prepared in two presses in one day. At Ischl, briquettes are prepared of columnar form with rounded edges.

According to a method introduced by Th. Nemke of Leopoldshall-Stuttgart (*D.R.P.*, 151,131), ground rock salt is moistened with water or salt solution and mixed with 0.75 to 1 per cent. magnesia. The briquettes made from the mixture are dried at 80° to 100° C. As a result of the addition of magnesia, a comparatively low pressure is required for compression, nevertheless the briquettes are hard and resist the action of atmospheric moisture.

In Germany the briquetting of salt for inland use would only lead to an unnecessary and disagreeable increase in the cost of salt; it might be of advantage, however, for export and other special purposes, where it is necessary

[1] Furer, *Die jüngste Fortschritte der Salinentechnik*, Hannover, 1899.

to protect the salt from the action of moisture and impurities for considerable periods of time. For a long time salt briquettes have been prepared in France for oversea export, particularly to French Guiana.

Flat lamellar salt briquettes (8) have recently been produced from the purest fine salt for the use of German troops on manœuvres and in the field. No. 9 shows a cone-shaped cattle-salt briquette made by the Hohensalza Rock Salt Co. from a mixture of rock salt, iron oxide, and wormwood powder. No special press is used, but the moist mass is stamped in a mould and slowly heated in a chamber kiln until it forms a strong block. Such denaturated cattle salts are tax free and very much in demand.

Brickmaking and other artificial methods of making stones from loam, clay, sand, chalk, etc., are closely allied to briquetting, but a detailed consideration of this important branch of industry is outside the scope of this book.

However, the briquetting of ores, metallurgical products, scrap metal, and the like must still be dealt with. In recent times this branch has developed in so peculiar and promising a manner that it appeared advisable to deal with the subject in a second, although considerably smaller volume.

SUPPLEMENT.

During the printing of the German edition of this book a new system of briquetting not described in it has been developed by experiment and improvement to such an extent that it can now enter into competition with other methods. It is the *Rónay Briquetting System*, owned by the Allgemeinen Brikettierungs-Gesellschaft m b H. of Berlin.

The method discovered by Rónay permits of the briquetting of pit coals, brown coals, ores, metallurgical products (especially flue dust), scrap metals and other waste materials by successive increases of pressure up to 1000 atms. by means of a hydraulic press. Complete ventilation of the material is provided; in most cases no binding material is required, and in the case of hard coal only small quantities (about 1 to 2 per cent.) need be added. The immense importance of this to the briquetting of pit coals will be readily understood from p. 225 *et seq.*

The Rónay method is already applied at several works (Friedenshutte in Upper Silesia, Sachsische Maschinenfabrik vorm R. Hartmann, Chemnitz, Sa.) for the briquetting of flue dust, ore refuse, and iron, steel, and metal waste on a technical scale. It gives good results, and is to be immediately introduced into other works for the same purpose and also for coal briquetting.

A detailed description of the process, with illustrations of the plant, including F. Muller's hydraulic press, and results of working, will be found in the second volume of this book.

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